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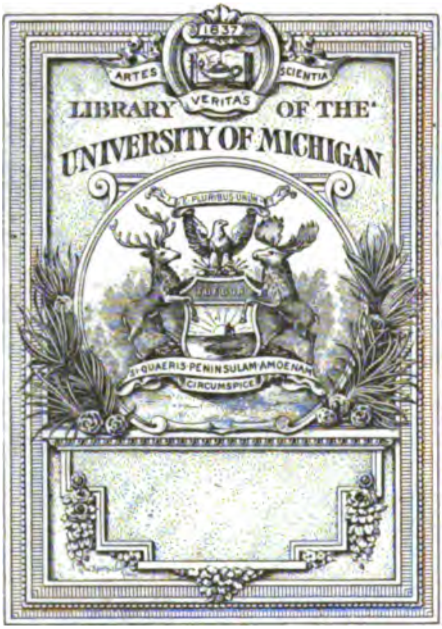

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Bulletin 138. **September, 1897.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

BOTANICAL DIVISION.

STUDIES AND ILLUSTRATIONS

—OF—

MUSHROOMS:

I.

By GEORGE F. ATKINSON.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1897.

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124. The Pistol-Case-Bearer in western New York.
125. A Disease of Currant Canes.
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STUDIES AND ILLUSTRATIONS OF MUSHROOMS: No. I.

BY GEO. F. ATKINSON.

With the publication of this bulletin it is purposed to begin a series of short illustrated articles on the fleshy fungi belonging chiefly to the so-called mushroom family. While there are several thousand different species of plants belonging to this group, which are more or less striking because of size, color, or form, they seem to have attracted very little attention from people generally. There is no reason why persons who have no technical knowledge of the science of botany should not know a dozen or more of the different common species, which appear through different seasons, in the same way that they come to know some of the common birds which visit us each summer.

In cities and in the larger towns there is a growing number of persons who are able to recognize, with a fair degree of certainty, the plant which is usually understood to bear the name of "*the mushroom*," and which appears chiefly during late summer and autumn in lawns, pastures, and similar open places in fields.* This plant sometimes occurs in great abundance, and the eagerness with which it is sought, by those who know its value as a food or relish, testifies to its importance as an article of diet.

If the worth of mushrooms as food was properly appreciated, even by the inhabitants of small villages and of the country, the ability to recognize several of the common species would not be difficult to acquire by those who would give an amount of attention to the subject equal to that which they bestow upon some other natural objects.

One reason why so little is known even of the common species, is because in many neighborhoods there is no one who can recog-

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***In the collection of some of the material and in making some of the photographs with which this bulletin is illustrated, I have been assisted by Mr. H. Hasselbring, a student of botany.**

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nize several of them, and thus impart the information concerning the kinds, and their prominent characters, to others. A slight degree of interest in these objects, with some observation as to form, the parts and the color of these fungi, with some one to whom the determination of the plant might be referred for a few times, would at length enable many persons to recognize a number of the commoner species, just as they come to recognize the more common birds. Many of us come to know the common birds from childhood without any technical knowledge of ornithology. It is by observation year after year, and association with our elders who have in a similar way come to know them, that we in turn know them.

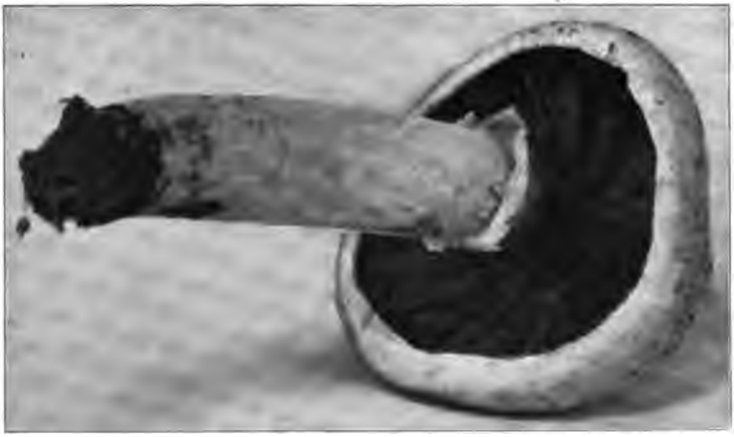
When once there are several in a neighborhood who can distinguish a few of the commoner mushrooms, this information might be handed down to generations, so that there would be no more difficulty for those who chose to observe carefully, to learn well several of the fleshy fungi, than there would be in coming to know many of the natural objects which we learn in a similar way. One might not be able to name the technical characters of the plant, but after observing it a number of seasons, it would be known on sight, or after an examination of the several parts, when these combined would present to the mind the characters of the plant as a whole, which makes up the concept of the species in the mind of those who do not make a pretense to a study of science. In addition to this if some attention in the schools could be given to teaching the general characters of these plants (not a technical treatment), it would lay the foundation for the gradual application of this knowledge in later observations.

Another reason why so few are able to recognize no more than one, is the general impression with many persons that there are but two species of this group, the "*mushroom*" and the "*toadstool.*" That is, many persons have the impression that there is but one "mushroom," the one which is "pink underneath," while all the others are "toadstools." Still others believe that all the members of the mushroom family can be separated into two groups, mushrooms which are edible, and toadstools which are poisonous. But this is all a mistake. There is no infallible test, like the "silver-spoon" test, nor any set of characters which will enable one to clearly separate these plants into two such groups. There are quite a number of these plants which are edible, a few which are very poisonous, a large number which are more or less indigestible, and a still larger number which have not yet been tested, and therefore their properties are not known. Botanists do not usually recognize any distinction between mushrooms and toadstools. Either name may be applied indiscriminately to any member of the group; that is, the terms are synonymous, except that in some cases the term *mushroom* is applied to the species of commerce, and which also grows in the feral state, while the term *toadstool* is applied to all others whether edible or not. The safest way is to learn to recognize certain species even though the number be few.

So much has been written in recent years upon the value of the edible mushrooms for food and the profusion in which they sometimes occur, that there is a growing desire on the part of many people to avail themselves of this article of wholesome diet. But warned by the difficulties which beset the ordinary fungus hunter in determining the species of these plants which are to be found, as well as by the crop of fatalities recurring every season, brought forth through a mistaken mushroom identity, many are deterred from making use of the quantities of nourishing and inexpensive food growing within easy reach. When one has trained himself to recognize one or more of the common edible species with certainty, they can be collected and eaten with safety. But until this can be done it is well to give all a "wide berth," unless there is some person for "referee" whom we know to possess either the technical knowledge necessary for discrimination, or who with no technical knowledge but with long personal acquaintance with the species, knows it just as we come to know some other natural objects by careful observation. It should not be understood, however, that all who profess to be connoisseurs in the art of recognizing "toadstools" as poisonous rightly judge all the species they list among their acquaintances.

The publication in a single bulletin of careful descriptions of but a few species, with several illustrations representing the important characters and the several aspects, which the plants assume at different stages of growth, it is believed will encourage a careful study, or observation of these few, so that they will become familiar to one and easy to detect. These few facts being assimilated and the beginner having become measurably familiar with a few forms, another pamphlet devoted to a few additional species can follow with profit.

In this bulletin only three of these fleshy fungi are illustrated and described. Two of these are edible and are very common during August and the autumn months in lawns, pastures, and similar open places. The third one is a *deadly poisonous* one, and is here illustrated and described, not only because a majority of the fatalities from "mushroom-eating" are probably chargeable to its seductive appearance and virulent properties, but also because it is perhaps sometimes mistaken by the novice for the common mushroom.

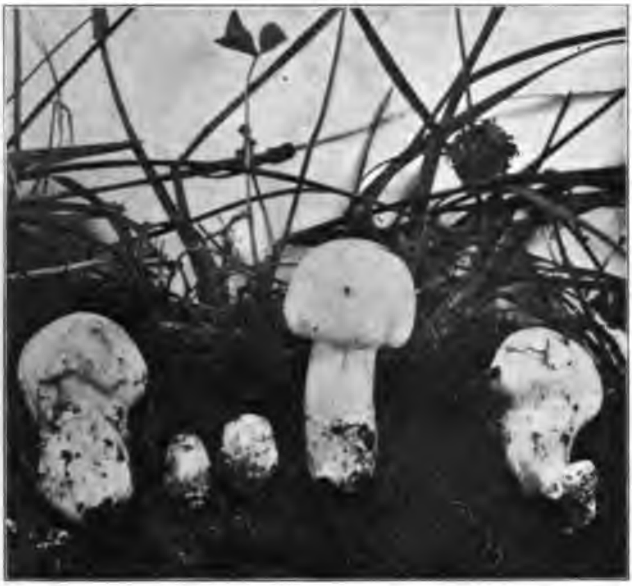


87. *Agaricus campestris. View of under side showing stem, annulus, gills and margin of pileus.*

THE COMMON MUSHROOM.

(*Agaricus campestris* L.)

Figure 87 is from a photograph of a specimen of the common mushroom (or pratelle) which has been pulled and is lying on the table. The parts are easily recognized and named. The stem (sometimes called the stipe) is cylindrical, or tapers a little toward the lower end. Near its upper end is a sort of a collar, usually termed a "ring" (or technically an *annulus*), which encircles it. This ring is very delicate in this plant, is white like the stem, of a very thin, satiny texture, and more or less ragged on the edge.

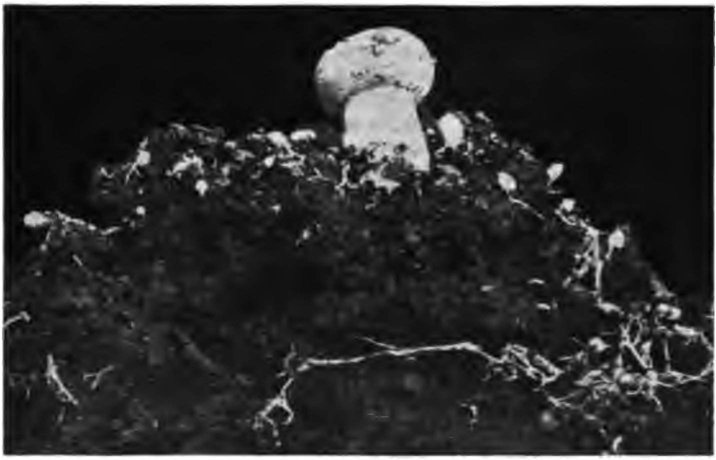


88. *Agaricus campestris. "Buttons" peeping through the sod. Some spawn at the left lower corner. Soil removed from front.*

The more or less circular expanded disk into which the stem fits is called the "cap" (technically the *pileus* which is the latin for cap). The upper portion, of which we can only see the margin in this figure, is convex (see figure 94). The surface is usually white, though sometimes brownish, and usually is covered by a thin layer of very delicate threads, while the flesh or inner portion is more compact, and is white also.

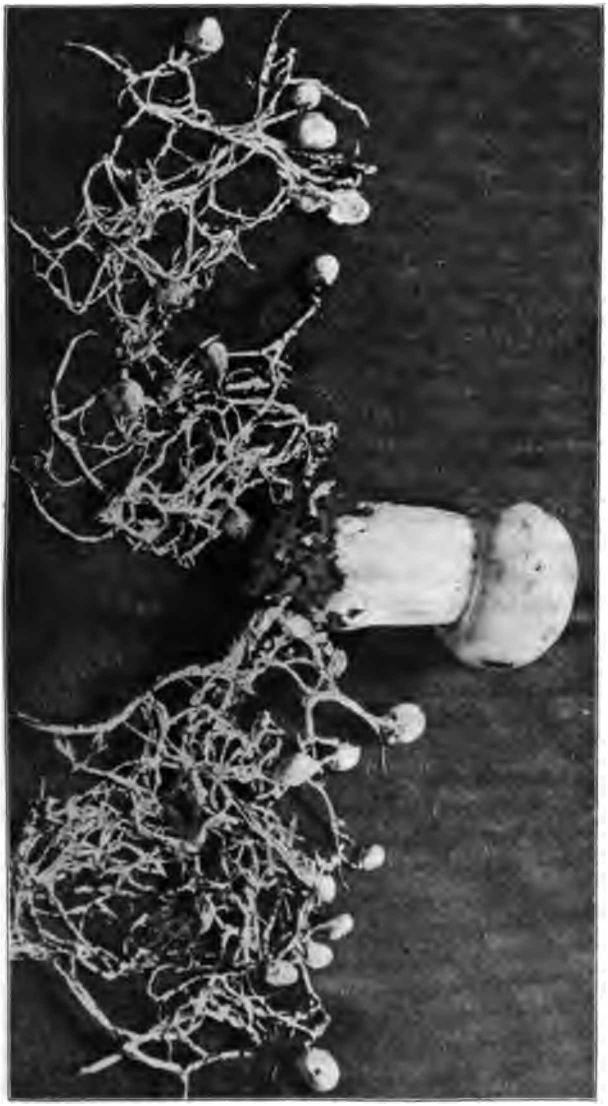
On the under side of the cap are numerous thin plates or "gills" (lamellæ), which radiate from near the stem to the margin of the cap. These are shown in figure 96 as fine radiating lines. They do not quite reach the stem, or, when they do they are not attached to it. When the plant is very young the gills are first white, but soon become a bright pink color, and in age change to a dark brown. The substance of the stem is less compact at the center, but the stem is not really hollow, though in some instances there are slight indications of it.

The parts of the common mushroom, then, are *cap* (*pileus*) *gills* (*lamellæ*) *stem* (*stipe*), *ring* .(*annulus*). We must bear in mind, however, that there are many other plants which possess just these same parts, but that they can be distinguished by the color, form, texture, etc., of the parts. Before examining the structure of the mushroom more closely we may enquire into its history. I mean its life history ; how it grows from a bit of white stuff to the size and form shown in the figure.



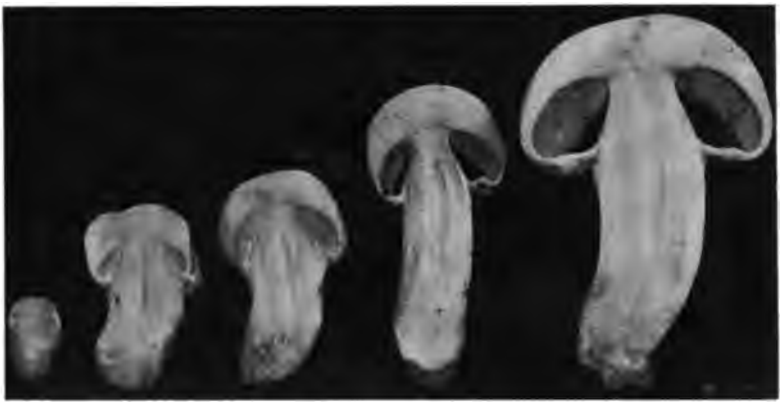
89. *Agaricus campestris. Soil removed to show large "button," and numerous small "buttons" attached to the "spawn" or strands of mycelium.*

If we turn to figure 88 we see some quite small plants of the common mushroom, which are just peeping through the sod, and are lifting their caps among the clover and blades of grass. The earth was removed from one side before the photograph was taken, so that the short stems in the soil are laid bare. At this age the plant is popularly called a "button," because of its



90. *Agaricus campestris. Soil washed from "spawn" and "buttons," showing the minute young "buttons" attached to the strands of mycelium.*

form. Two quite small "buttons" still underneath the sod have been bared by the removal of the earth. At the left lower corner of the picture are some small white bits of mushroom stuff yet "unformed." This is known popularly as the "*spawn.*" In another photograph (figure 89) this "spawn" is better shown. This has also been uncovered. Here the spawn is shown to consist of rather coarse whitish strands, or cords. One large button is present, and scattered on either side are several minute rounded white masses. These are miniature buttons, and are very young. Some of them can be seen attached to the strands of spawn. Figure 90 is from a photograph of the same group, a little enlarged, after the soil has been washed away from the spawn and the buttons. Here the connection of the very young buttons with the cords of spawn can be very clearly seen. These strands or cords are made up of numerous minute whitish threads, known to botanists as *mycelium.* In the group of fungi to which the mushroom belongs, the mycelial threads are often interwoven into such strands in somewhat the same way as fibres are woven into cords or ropes, though not in such regular fashion, and of course they grow in this form. They are often spoken of as cords or strands* of mycelium. In the soil the mycelium grows and forms new strands, obtaining its nutriment from the decaying humus and other vegetable matter.



91. *Agaricus campestris. Sections of "buttons" of different sizes, showing formation of gills and veil covering them.*

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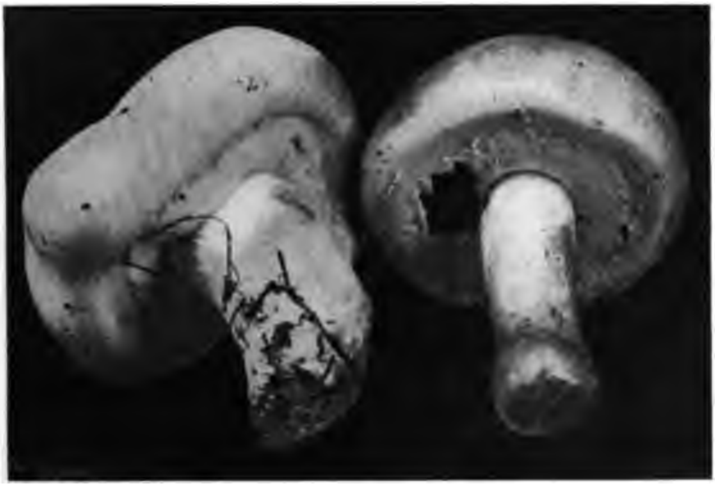
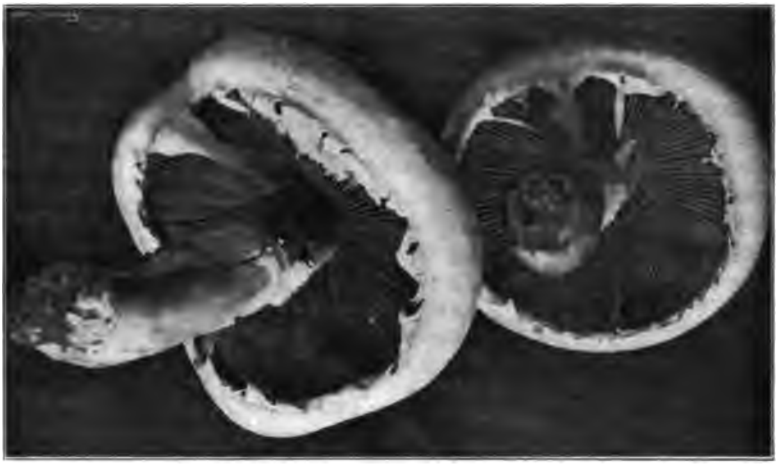
* The term *rhizomorph* is also applied to these strands of mycelium.

At certain points on the strands the mycelium grows to form these rounded bodies known as buttons. At first they are of the size of pin heads, and soon increase to the size of bird shot, then peas, when a minute stem begins to appear with the button growing on its free end. This increase in size as well as the increase in the length of the stem lifts its head and the upper part of the stem from the ground, and it rapidly expands into the mature mushroom. If we split several of these buttons of different sizes down through the cap and the stem, we shall see the curious way in which the gills and the ring are formed. The photograph shown in figure 91 represents five of these stages. In the smaller ones the young gills in the sections resemble two eyelets. These have been covered over on the outside by the mycelium growing downward from the cap, and upward from the stem, the ends of the thread interlacing to form a veil which extends all around the stem covering the constricted portion at the junction of the stem with the button. If we cut across the button at this point the gills would show as a ring with the veil outside.

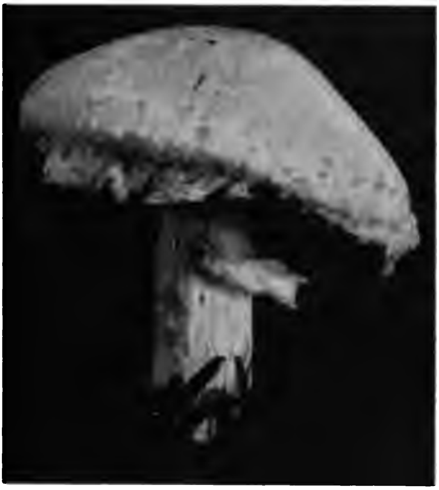


92. *Agaricus campestris. Nearly mature plants, showing veil still stretched across the gill cavity.*

As the plant grows all these parts increase in size, the gills extending downward by the growth of the mycelium in radiating lines to form the plates. As the cap expands the veil is stretched and a cavity appears between the free edges of the gills and the veil. If we now look at figure 92, which is from a photograph of the underside of two nearly mature plants, we can see the veil stretched over the gills from the margin of the pileus to the stem. Here we can see how delicate the texture of the veil is, and how easily it is torn. During these stages the gills are pink in color except in the very youngest, when they are white, unless by some accident the plant becomes old before the veil breaks. The cap now expands more and more, and the veil is ruptured as shown in figures 93 and 94. In both of these photographs the fragments of the veil are shown clinging partly to the stem, and partly to the margin of the pileus where the dripping tender fibrils lend a wierd aspect to the spectre-like plant as it lifts its head from the sod at night.

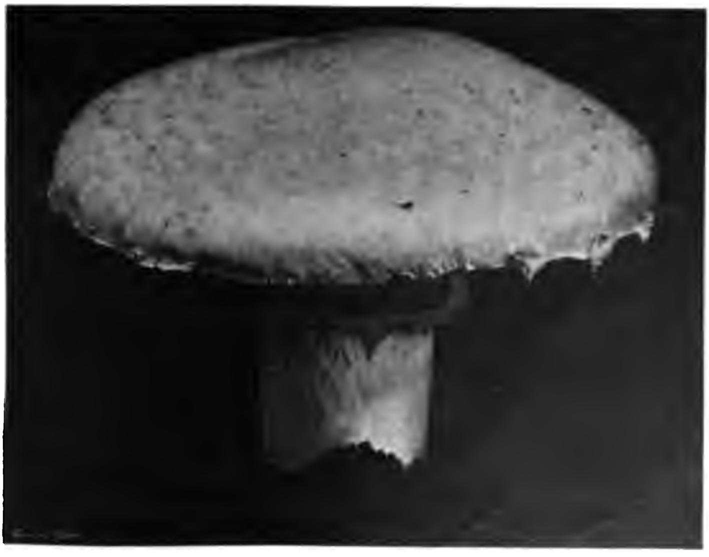


93. *Agaricus campestris. Under view of two plants just after rupture of the veil, fragments of the latter clinging both to margin of pileus and to stem.*



94. *Agaricus campestris. Plant in natural position just after rupture of veil, showing tendency to double annulus on the stem. Portions of the veil also dripping from margin of pileus.*

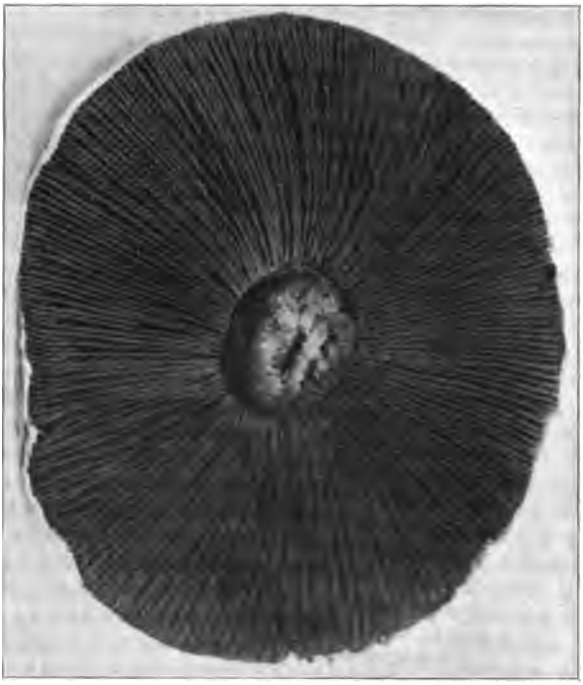
Because of the very delicate and fragile character of the veil, it does not in many cases remain clinging to the stem as a complete ring, and it is also in some cases quite evanescent. In figure 87 the ring is well formed. In figure 94, where the photograph was taken soon after the rupture of the veil, the edge of the ring has a tendency to be double where the threads break away from the inner and outer edges of the cap. In some other mushrooms this double character of the ring is quite pronounced, but here it is quite rare.



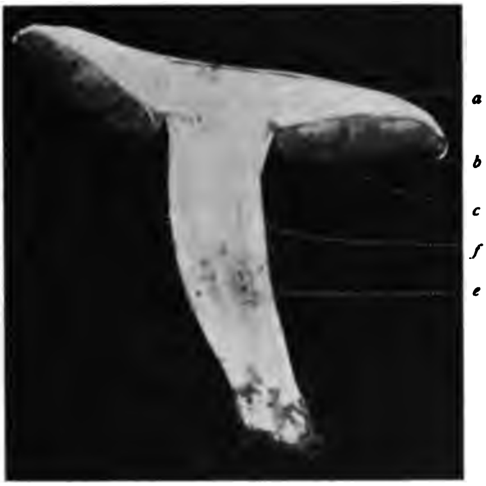
95. *Agaricus campestris. Plant showing loose fibrils on surface of pileus drawn into triangular scales.*

Sometimes the fibrils on the surface of the pileus are drawn into triangular patches which point outward, as shown in Fig. 95. This gives a scaly appearance to the surface of the pileus. While in the ordinary form of this mushroom, the surface of the cap is white, often the fibrils on the surface are brownish. In one form of the plant the triangular scales are dark brown, and give it a quite different aspect. This dark scaly form sometimes appears early in the spring.

If we note the position of the gills carefully, as we can by referring to the photograph (represented in Fig. 96) of the underside of the pileus, it will be seen that they do not quite reach the stem and are rounded at the inner end. They are thus only attached by their upper edges to the under surface of the pileus. Between the longer ones are shorter ones which reach, some only a little distance from the margin of the pileus, while others reach half or two-thirds the way to the stem. The space is thus used to good purpose, and the entire under surface of the pileus is crowded with these gills or lamellæ.

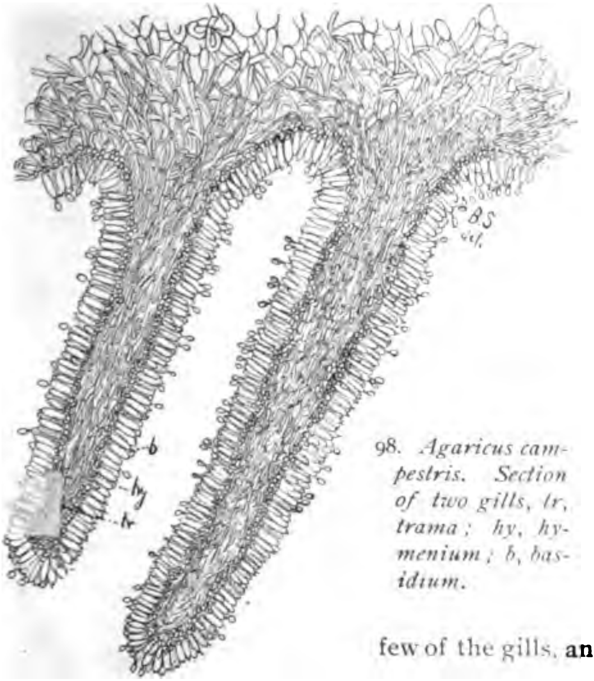


96. *Agaricus campestris. View of underside of pileus, showing arrangement of gills.*



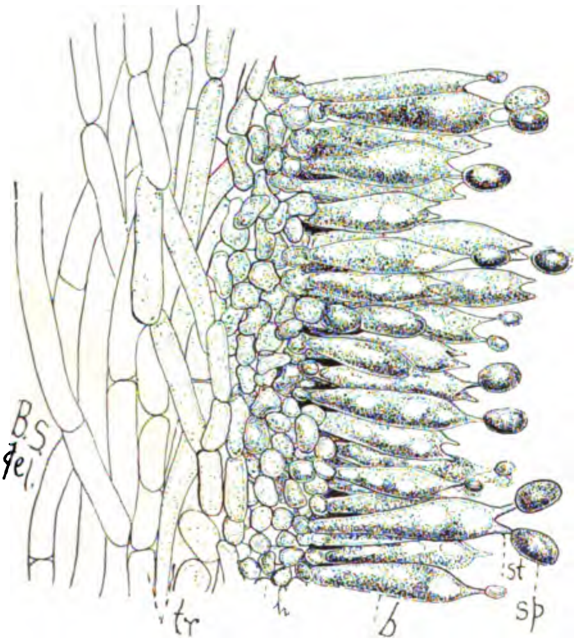
97. *Agaricus campestris. Longitudinal section through stem and pileus: a, pileus; b, portion of veil on margin of pileus; c, gill; f, fragment of annulus; e, stipe.*

The shape of the gills as well as their position can be well seen in Fig. 97, which is a photograph of a longitidunal section of a mature plant. On the right is represented an entire or long gill, which reminds one somewhat of the blade of a knife. On the left are represented two of the short gills which lie in front of one of the long ones. The surface of these gills forms what is termed the fruiting surface of the mushroom, or *hymenium*. The structure of the gill is quite specialized, and here we find parts which are characteristic of the great group of plants to which the mushroom belongs. If we cut very thin slices or sections across a few of the gills, and mount them



98. *Agaricus campestris. Section of two gills, tr, trama; hy, hymenium; b, basidium.*

in water under a thin cover glass for examination with the microscope, we shall see revealed these peculiarities. Fig. 98 represents such a section of two gills. We see here that even this part of the plant is largely made up of fine threads of mycelium closely interlaced and woven together. Through the center of the gills the mycelium continues down from that of the pileus. This middle portion of the gill is termed the *trama*. Just outside of this, on either side, is a layer several cells deep of short cells termed the *hymenium*. From the cells of the hymenium are borne the club-shaped bodies which stand closely parallel in a layer on each surface of the gill. Each one of these club-shaped cells is termed a *basidium* (the latin word for club). Each basidium bears at its free extremity two slender processes which lend to the basidium a forked appearance. Each one of these processes is termed a *sterigma** (plural, sterigmata). Each sterigma bears a spore, which is a nearly rounded or oval body, so that each basidium in the common mushroom (Agaricus campestris) bears two sterigmata and two spores, while in a majority of the members of the group the basidia bear four sterigmata and four spores.



99. *Agaricus campestris. Portion of gill in section; tr., trama; hy., hymenium; b., basidium; st., sterigma; sp., spore.*

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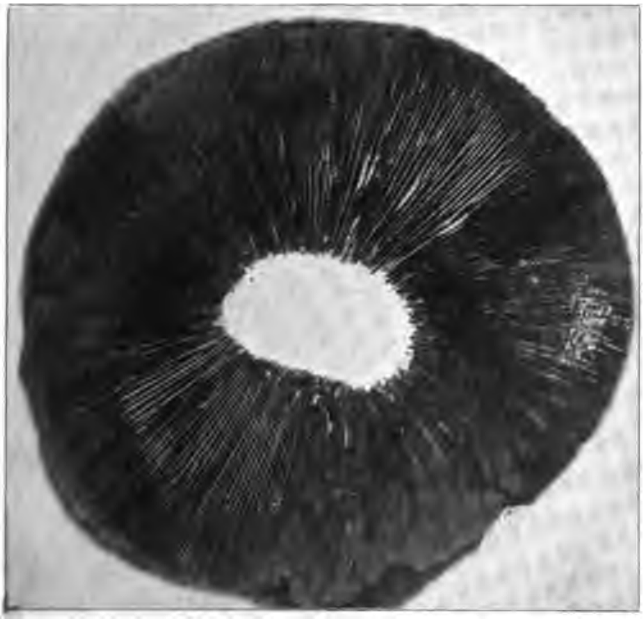
* Pronounced ster-ig′-ma; ster-ig′-ma-ta. Figs. 98 and 99 were drawn from nature by Dr. Bertha Stoneman.

At maturity these spores easily fall away from these little forked processes (sterigmata) and give a dark brown coating to the objects on which they fall. The spores are purple brown in color, and as they mature their number on the surface of the gills accounts for the dark brown color of the latter. One can obtain what is sometimes called a "spore-print" of the under surface of the mushroom, or arrangement of the gills, by cutting off the stem and placing the pileus on white paper for a few hours. It should be placed where there are no drafts of air and covered with a bell jar or other closely fitting vessel to avoid the shifting currents of air, since the spores are so light they would not fall perpendicularly, but drift and thus confuse the print. A photograph of such a spore print of Agaricus campestris is shown in Fig. 100, the dark lines representing the long heaps of spores where they fell from the surfaces of the gills.



100. *Agaricus campestris. Spore print.*

BRIEF DESCRIPTION OF AGARICUS CAMPESTRIS.

The common mushroom (Agaricus campestris) grows in lawns, pastures and similar places. It averages 5–8 cm. (2–3 inches) in height, the pileus being 5–12 cm. in diameter.

Pileus.—The cap or pileus is convex or more or less expanded, the surface being nearly smooth, or more or less silky hairy, these fibrils sometimes being collected into triangular scales. The color of the surface is usually white, but varies to light brown, while the flesh is white.

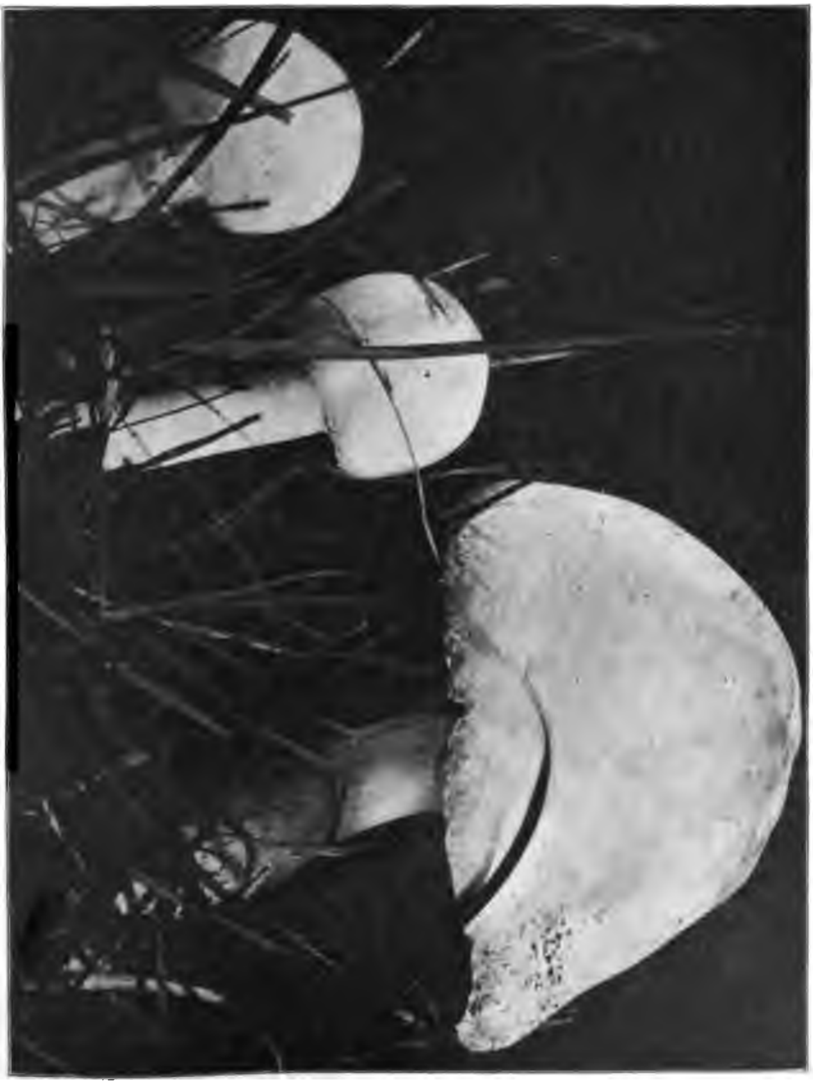
Gills.—When the plant is very young the gills are first white, but soon become pink, and later purple brown or dark brown from the numerous purple colored spores on the surface. The gills are free from the stem, and rounded on their inner ends.

Veil and Annulus.—The veil is thin, white, silky and very frail. As the pileus expands the veil is stretched and finally torn, when it clings as a thin collar or ring (annulus) around the stem, or fragments dangle from the margin of the pileus. As the plant becomes old, the annulus shrivels up and becomes inconspicuous.

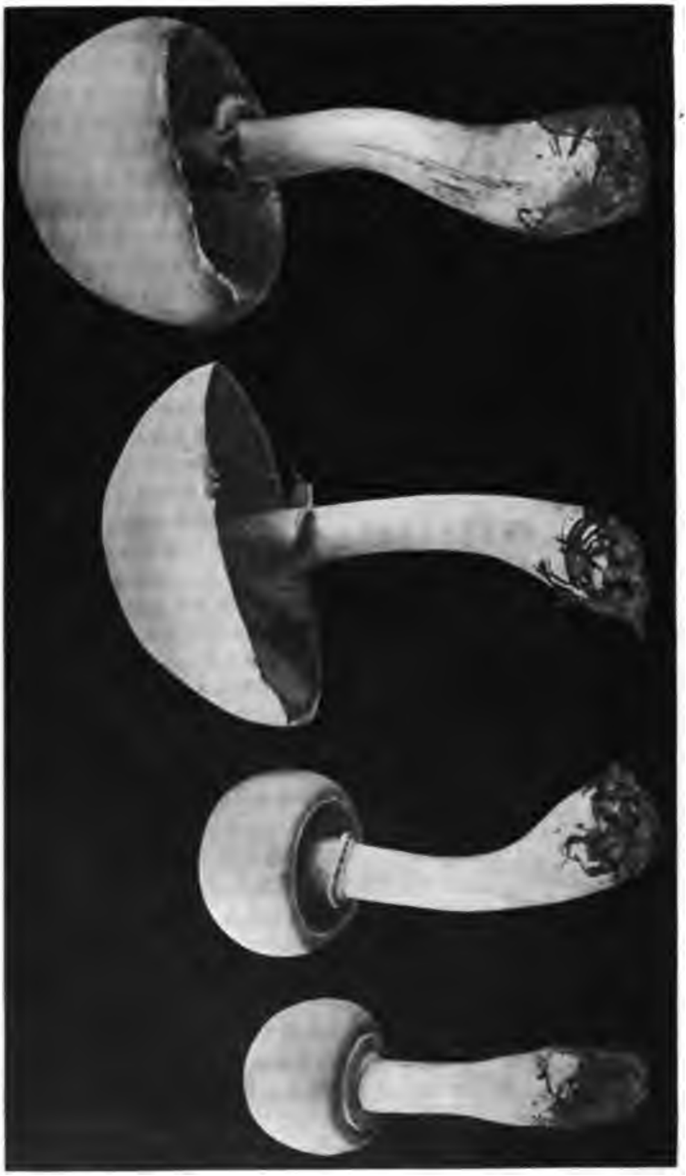
Stem or Stipe—The stem is white, nearly cylindrical, or slightly tapering at the lower end. It varies from 3–8 cm. long and 1–2 cm. in diameter. The flesh is solid, though less firm at the center.

GROWTH OF THE MUSHROOM.

The mycelium in the form of delicate threads or stouter strands (called spawn) lives in the soil, absorbing in solution certain of the substances of decaying vegetable matter, which it appropriates for growth and increase. It lives here for several months, or in some cases for years, before developing the fruiting portion which is the "mushroom." This first appears as a minute rounded mass on the strands of mycelium. It grows in size to form a "button" with a stem. The young gills are formed by the mycelium growing downward in radiating ridges from the under side of the margin of the button, the gills at first being covered by a delicate veil of interlacing threads. As the pileus expands it bursts through the sod, ruptures the veil, when the characters of the fully formed mushroom appear.



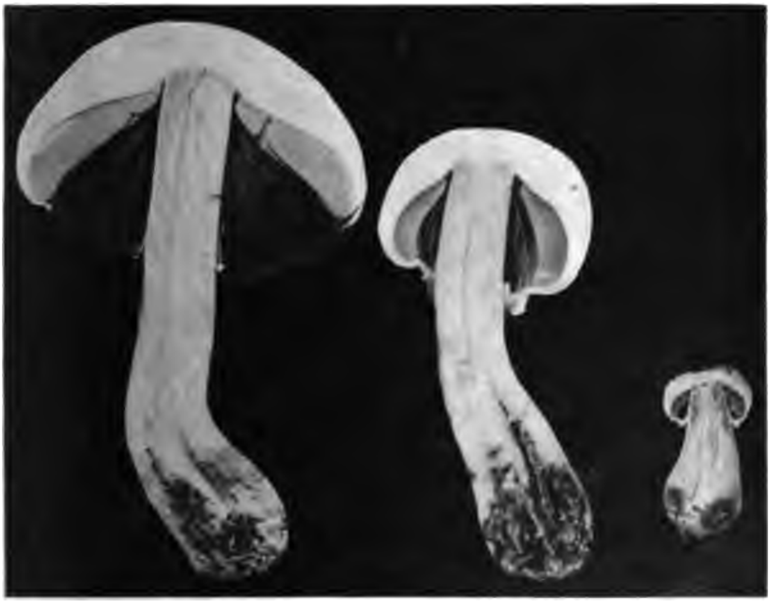
101. *Lepiota naucina. Plants natural size in lawn.*



102. *Lepiota naucina. Plants natural size in four stages; showing formation of annulus from veil.*

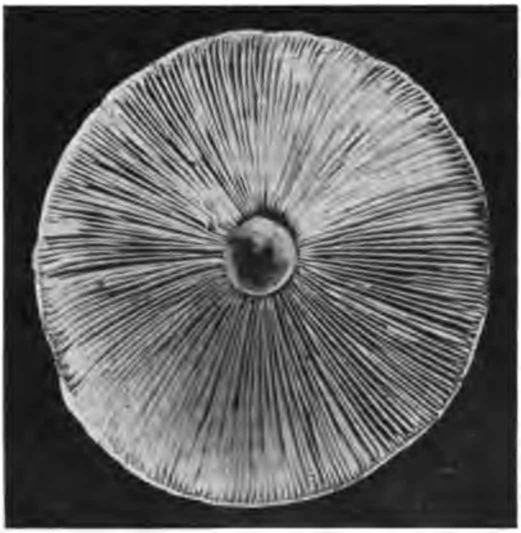
LEPIOTA NAUCINA Fr.

The next mushroom, or toadstool, described here is one which occurs during the same season as the Agaricus campestris (common mushroom), and in similar localities i. e. in lawns, pastures, etc. It is known as *Lepiota naucina*, the short stemmed parasol, or smooth Lepiota. Because of this similar seasonal and local occurrence it might at first be taken for the Agaricus campestris, especially since the plant is about the same size, is usually white, or light tan, and possesses an annulus. The gills, however, are white from the youngest stages to maturity, only becoming pinkish when very old, and drying a light brown or dirty pink.



103. *Lepiota naucina. Section of three plants of different ages.*

A photograph of this plant as it occurs in lawns is represented in figure 101. On looking at the gills of a freshly growing plant one would readily distinguish it from Agaricus campestris, because of their white color. The spores of this plant are white, as one can readily determine by making a spore print as shown in figure 105. The color of the spores is one of the most constant characters which the members of the mushroom family possess, and in studying these plants some of the spores should be caught on white paper for the purpose of determing their color. Figure 102 represents four different sizes and stages of this Lepiota. In the plant at the left the veil still covers the gills. In the next one it has broken away from the margin of the pileus and forms a collar around the stem. In the third the pileus is still more expanded. In figure 103 are shown sections of three plants of different ages. We see here that the gills are free from the stem. The general characters, then, with the exception of the color of the spores, are the same as those of the Agaricus campestris.



104. *Lepiota naucina. View of gills on under surface of pileus.*

This distinguishing feature, the different color of the spores, is regarded as such an important one that it is used to separate genera, and so this plant is placed in the genus* Lepiota instead of in Agaricus, though all the other generic characters are identical.

A few specific points might be described more in detail. The pileus is usually quite smooth, though in some specimens the surface shows numerous very fine cracks, which give it a granular appearance. The pileus is usually very symmetrical, rounded when young and strongly convex when mature. The flesh is soft and white but remains much firmer in age, and when picked, than does that of Agaricus campestris.

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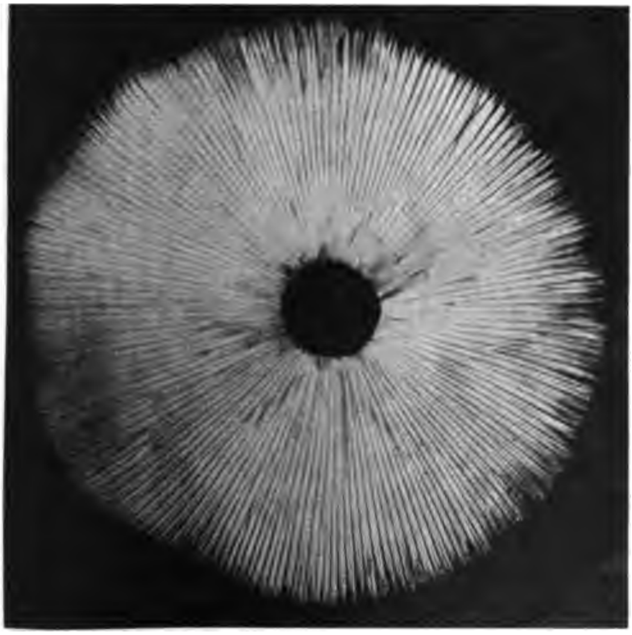
* Subgenus according to some.

The veil is also firmer than in the case of Agaricus campestris. It separates cleanly from the margin of the pileus, as well as from the stem, so that it forms a perfect collar or ring, which in some cases may be moved on the stem. The lines of separation and the firm veil are clearly shown in the plant at the left hand in figure 102. In old specimens the ring sometimes is torn, and may disappear.



105. *Lepiota naucina. Spore print.*

The stem is nearly cylindrical, 5–10 cm (2-4 inches) long and ¾-1½ cm in diameter, and is slightly enlarged or bulbous below. It is nearly hollow, as shown in figure 103, though this cylindrical space is usually stuffed with loose cottony threads.

The Lepiota naucina is an edible species, and is valued as highly as the Agaricus campestris by many who have eaten it.

Like the Agaricus campestris it is also an European species, though the descriptions in European botanical works are quite meager, and much confusion exists in reference to the shape of the spores. The spores of the European specimens are usually described as "round," though Mr. Massee in his British fungus Flora describes them as subrotund. This confusion regarding the shape of the spores has led to the belief on the part of some in America that our plant is different from the European one, for the spores in our plant are elliptical or oval, not rotund. For this reason the plant in America has been called by some *Lepiota naucinoides.* After careful study and observation of our plant, and by comparison with illustrations and descriptions of the European species, the conclusion is irresistible that the two are identical. In order to have our plant compared with the European one the writer sent some specimens to Mr. George Massee, of the Kew Herbarium, London, England. The director of the Herbarium has kindly replied that our plant is "*Lepiota naucina*, *typical.*"

AMANITA PHALLOIDES FR.

(*The deadly amanita.*)

The third and last plant described here is one of the "deadly" amanitas, the *Amanita phalloides.* It is mentioned here not only because it is probably responsible for a majority of the deaths from eating mushrooms, but because by the novice it might well be taken for either the Agaricus campestris or Lepiota naucina, especially the latter. It usually occurs in woods, while the two other plants here described occur in open places. The amanita phalloides sometimes occurs in borders of lawns near woods. I have this year in the early part of September found four or five specimens of this deadly amanita in the border of one of the lawns on the campus of Cornell University.

One form of the plant is represented from a photograph in figure 106. It is pure white and possesses an annulus or collar, *but what is most important the base of the stem rests in a cup-like envelope called the volva.** In this specimen the margin of the volva is cleft into three parts which are somewhat spreading. This specimen was collected in a beech woods along a damp ravine in the month of July. The veil has separated by an even line from the margin of the pileus and hangs as an annulus in the form of a broad collar from near the upper end of the stem.

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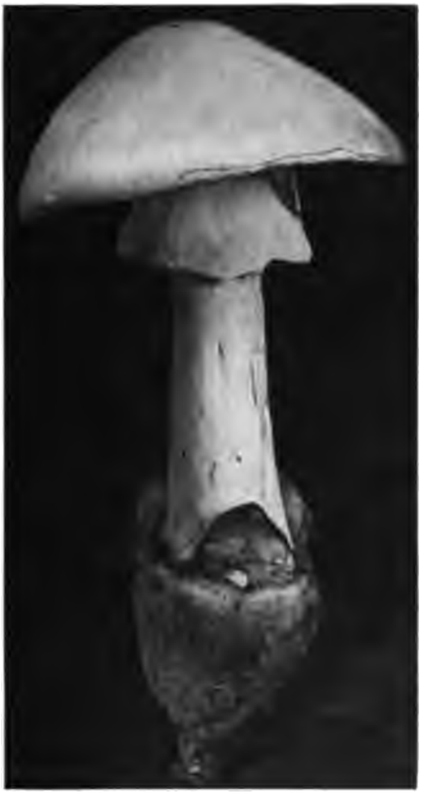
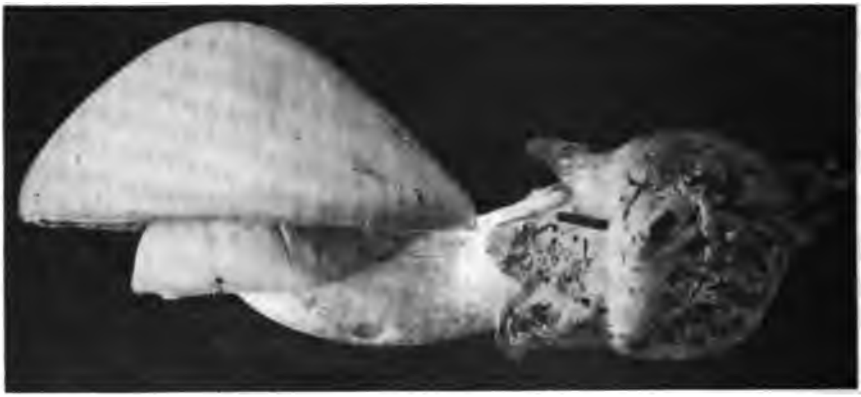
*Popularly termed the "poison-cup," "death-cup," etc.



106. — *Amanita phalloides. White form, showing pileus, stipe, annulus and volva.*

The pileus in this form is smooth, viscid to the touch, and pure white, as is also the annulus, stem and volva, though the latter is soiled by particles of earth. The stem is nearly cylindrical, tapering slightly from the bulbous base. It is hollow, or stuffed with cottony mycelial threads. The gills are usually pure white, even in age, and are nearly free from the stem. When decaying the plant emits a very disagreeable odor.

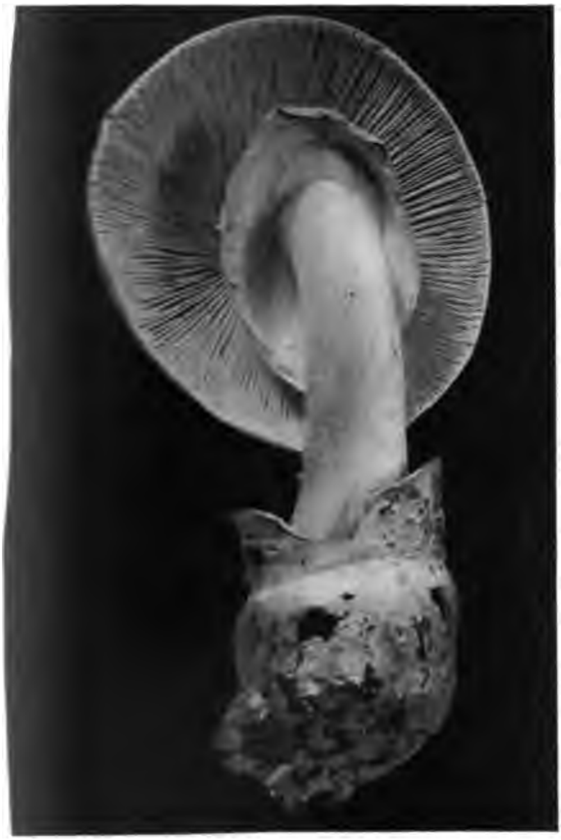
Because this plant is sometimes found in lawns and in fields bordering on the woods great care should be exercised in the collection of the Agaricus campestris, and especially of the Lepiota naucina, to be certain that a *volva* is not present on the lower end of the stem. Until one is certain he knows the plant he is collecting, the plants should not be picked by simply taking hold of the pileus, but the stem should be carefully dug up. In the case of some plants of Amanita phalloides which I found in a lawn the stem was about 7 cm (nearly 3 inches) deep in the ground, so that by simply picking the plant by the cap, the most important character, the *volva*, would be lost, and by a novice the plant might be taken for the Lepiota naucina. Some of the specimens of Amanita phalloides which I have collected this summer might even be taken by a novice for the Agaricus campestris if the volva were not obtained. In some of the young specimens the gills were *decidedly pink*, so much so that several persons who saw the plants remarked on the pink color of the gills and they were not aware of the significance of this fact. It should be stated, however, that the pink color of the gills in these young specimens of Amanita phalloides is not nearly so deep as the pink color of the gills of Agaricus campestris.



107. *Amanita phalloides. Plant turned to one side after having been placed in a horizontal position by the directive force of gravity.*

A pure white plant very closely related to this white form of Amanita phalloides, which occurs in the spring or early summer is considered by some to be a distinct species, called *Amanita verna.* These pure white forms of some amanitas, because of their deadly poisonous property, are sometimes called the "destroying angel."

Shortly after the pileus of these plants breaks through the volva, and the stem is elongating, they are very sensitive to the directive influence which the earth, or gravity, exerts on the growth of many plants. One of the reasons why the plant grows in an upright position is that this influence directs it away from the earth. This is easily observed in placing young and

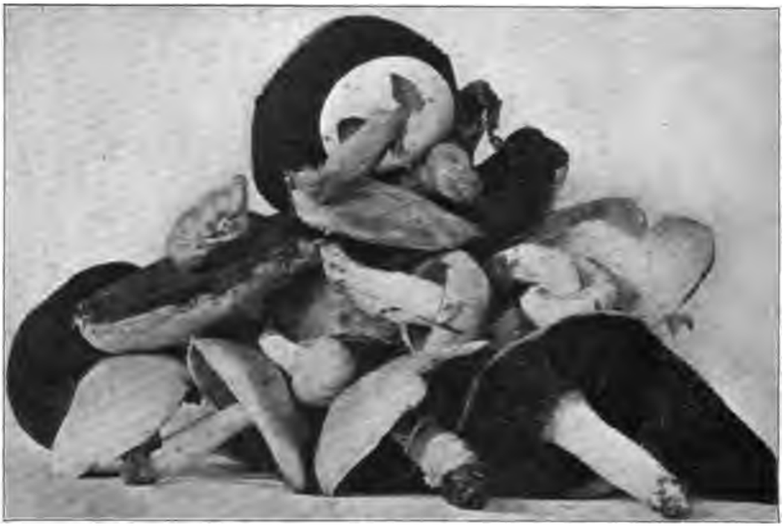


108. *Amanita phalloides. View of undei side of pileus, showing form and position oj annulus and volva.*

109. *Amanita phalloides. Another view of Fig. 22.*

rapidly growing specimens in a horizontal position. In a few hours the stem end near the pileus begins to turn upward, and the plant has taken the form shown in figure 107. This plant was lying on its side for only about one or two hours, and the stimulus which it received in this position during the short period caused it to turn after it had been stood upright again. A view of the underside of this same plant is shown in figure 108, and in figure 109 a diagonal view, which represents well the form and attachment of the annulus to the stem.

Other forms of the Amanita phalloides occur in which the pileus is yellow, or greenish, instead of white, and sometimes bits of the *volva* remain adherent to the surface of the pileus in the form of whitish patches. There are other species of the genus Amanita which cannot be discussed in this bulletin, but will be illustrated in a future one.

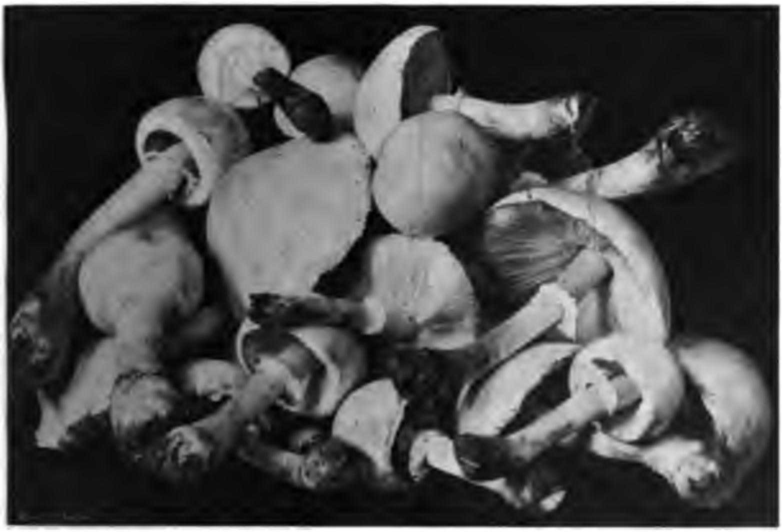


108. *Agaricus campestris.*

Those who are not familiar with the three plants here illustrated, and who desire to be able to recognize them, are advised to search the pastures, etc., for the Agaricus campestris and Lepiota naucina, and also the damp woods for the Amanita phalloides, and to compare the plants found there with these descriptions. In this way familiarity with the species may be acquired which will serve as a means of determining them in the future.

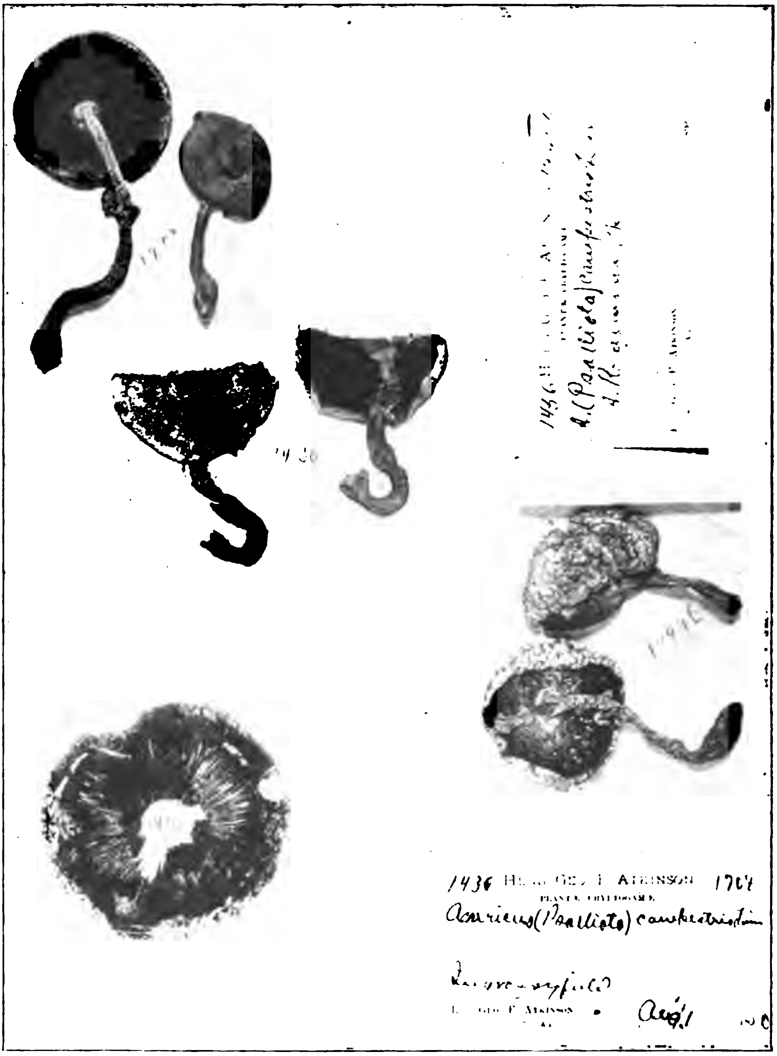
The two former species often occur in such abundance during the autumn that basketsful of them can easily be gathered.

Those who wish to preserve these plants in the herbarium, or for future determination if there is not an opportunity to determine them in the fresh state, should dry them carefully after first taking full notes on form, color, size, texture, position, etc., of the various parts of the plant. Full directions for taking careful notes, or for drying cannot be given here, but may be attempted at some future time. The Agaricus campestris and Lepiota naucina can be dried in the sun, and may then be kept in boxes. Or when moistened again a little by dew, may be pressed lightly between sheets of absorbent paper, and then glued to herbarium sheets or folded in paper packets as shown in figure 112. Specimens of Amanita phalloides contain proportionately more water and consequently shrivel more in drying. They are apt to decay before they can be dried in the sun, except in very bright weather. Artificial heat can be used but this causes the plants to shrivel still more unless the process of drying is very slowly accomplished. In this case they should be placed over



111. *Lepiota naucina.*

the source of heat where currents of warm air are rising and then dried very slowly. In the case of the large and watery ones some cut the plants down into two halves through the stem, then cut out the inner fleshy part of the pileus and stem, and then


1436 Herb. Geo. F. Atkinson 1901
Agaricus (Psalliota) campestris
Aug. 1

112. *Agaricus campestris. Photograph of sheet from herbarium.*

placing the inner faces on an herbarium sheet, dry under pressure by hot driers which should be changed frequently. This process preserves well the external form and characters where properly done. If this rule is followed other plants should be preserved whole. In order to have a record of the characters, however, careful notes on all the characters should be taken while the plants are fresh, since so many of the important ones are evanescent and disappear in drying. The notes can be supplemented by pencil sketches or even by photographs if the collector so desires. A spore print should also be preserved for a record of the color of the spores, since one cannot use the color of the gills in all cases to determine that of the spores, and a few spores under the microscope do not in many cases give the tint which a mass of spores show, and which is very important to know. Some liquid fixative like gum-arabic should be spread on the portion of the white paper covered by the pileus previous to taking the spore print so that the spores will adhere well to the paper; or they may be later fixed by using material like Rouget's fixative with an atomizer, though with this latter treatment, the figure of the print is apt to be disturbed somewhat.

In the preparation of mushrooms for the table, information may be obtained from other sources if it is not already at hand, since we cannot here enter into a discussion of the culinary treatment. But as a matter of course all wormy and very old specimens should be discarded.

In communities where there is a desire to become acquainted with the common fleshy fungi, those interested might combine to form a "mycological club." A number of persons thus associated together might purchase a small reference library to be kept in a club room, at a trifling cost to each member. Here specimens could be brought, the literature and illustrations compared and an exchange of opinions between the members on the various plants would assist in a more ready determination of the plant, and in the acquisition of useful information as to occurrence, habits of growth, etc. Some few in such a community would become more expert than others, and could at length be regarded as "specialists" to whom more doubtful matters could be referred, or who themselves in doubtful cases could consult by correspondence with some one possessing greater opportunity at some botanical center. Such a club would undoubtedly become interested in other nature subjects which would afford both pleasure and profit.

A few books and pamphlets which might be obtained to start such a reference library are enumerated below with the price. Some of the larger useful books are not here mentioned because of the cost.

Farlow, W. G. Notes for Mushroom-Eaters (published in *Garden and Forest*, January and February, 1894). Published also as a separate. 25 cts.

Gibson, W. H. Our Edible Toadstools and Mushrooms. $7.50.

Massee, G. British Fungus Flora. 4 vols. $2.00 each.

Peck, C. H. Mushrooms and their Use. 50 cents.

A recent work by Dr. Peck, with many colored illustrations, published in the 48th annual report of the N. Y. state museum of natural history, and issued as a separate, has been exhausted, but a new edition is being published. This can be obtained when issued for about one dollar by applying to S. B. Griswold, State Library, Albany, N. Y.

A Text Book of British Fungi, by Delisle Hay, contains a fairly good glossary of terms used in descriptive works, and also an analytical key arranged after W. G. Smith. A chart of colors which is useful in taking notes can be found in Saccardo's Chromotaxia, 60 cents. This latter as well as Dr. Peck's "Mushrooms and their Use," can be obtained from the Cambridge Botanical Supply Co., Cambridge, Mass. This pamphlet contains also a list of other works on fungi.

GEO. F. ATKINSON.

Bulletin 139. **October, 1897.**
Cornell University Agricultural Experiment Station.
ITHACA, N. Y.
HORTICULTURAL DIVISION.

THIRD REPORT UPON
JAPANESE PLUMS.

By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1897.

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The regular bulletins of the Station are sent free to all who request them.

BULLETINS OF 1897.

124. The Pistol-Case-Bearer in Western New York.
125. A Disease of Currant Canes.
126. The Currant-Stem Girdler and the Raspberry-Cane Maggot.
127. A Second Account of Sweet Peas.
128. A Talk about Dahlias.
129. How to Conduct Field Experiments with Fertilizers.
130. Potato Culture.
131. Notes upon Plums for Western New York.
132. Notes upon Celery.
133. The Army-worm in New York.
134. Strawberries under Glass.
135. Forage Crops.
136. Chrysanthemums.
137. Agricultural Extension Work, sketch of its Origin and Progress.
138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.

THIRD REPORT UPON JAPANESE PLUMS.

In two bulletins (Nos. 62 and 106) we have made reports upon the history and varieties of plums which have recently come into this country from Japan. A crop of many of the varieties upon the Cornell grounds in 1897, enables us to make a third report. The nomenclature of this class of plums is in the greatest confusion, and the plums themselves are too little understood to warrant unqualified recommendation. It will be several years yet before we can expect to thoroughly classify our knowledge of them. This confusion is of itself a strong reason why these reports should be made, for, while we do not expect that we have arrived at a full knowledge of the varieties, the confusion would increase rather than diminish if no attempt were made to record the tests from year to year. The confusion among these plums has arisen because the Japanese class-names have been retained in this country, and because various parties have disseminated the varieties under numbers or without names. The writer has therefore given new names to varieties which are passing under class-names and numbers; but the renaming of any variety is not to be regarded as a recommendation of it. At first it was intended to include in this report copious extracts from the current press respecting the varieties of Japanese plums, but it so frequently happens that persons have different varieties under the same name that there is danger of adding to the confusion rather than diminishing it by too free quotations from contemporaneous writings. We have merely set down the behavior of such varieties as have fruited with us this year, making such corrections of nomenclature as seem to be necessary in order to clarify the subject.

I am still convinced that the Japanese plums have come to stay. By this I do not mean that they are destined to supplant the domestica and native plums, but that they are bound to supplement those types with varieties that are adapted to particular purposes and conditions. As a class, they are vigorous, hardy and productive in tree, and the fruit is handsome, long keeping, and covers a long season.* Thus far, they have been comparatively free from black-knot, and until this year our trees have not been seriously attacked by the shot-hole fungus or leaf-blight. During the past season, however, this leaf-blight has been much worse upon the Japanese varieties than upon the domesticas alongside them, and this, too, in spite of the fact that they were thoroughly sprayed. The leaves did not drop to any extent, however, even though they were badly riddled by the fungus.

The following notes must not be taken to be complete or final descriptions of the varieties. In many cases they are made from the first crop on young trees. But they record the present state of our knowledge respecting this new and much confused type of fruits. It is our habit to set the wood of new varieties (either as buds or grafts) in the tops of Lombard plums, and several of the varieties have been fruited only in this way. The pictures are all natural size, and are made from average specimens. The reader should be told that pictures always look smaller than the objects, even though they are of the same size. Other true pictures of the fruits and trees of Japanese plums may be found in our Bulletin 106. That bulletin attempts to describe all the varieties known at that time (1895), but the present report concerns itself only with those varieties which we have fruited.

A most perplexing feature of the Japanese plums is the variation in the season of ripening in different years. In our first Japanese plum bulletin, we said that the Burbank "is from two to four weeks later" than the Abundance. We had not then fruited the varieties side by side. In our second bulletin, we said that the difference in ripening was only" a week or two," and added that upon our grounds the Burbank, in 1895, "was less than a week later than Abundance." These same trees were compared this year (1897), and the Burbank was fully three weeks later than Abundance. In 1895, the Red June ripened from July 28 to August 1; this year the fruit upon the same tree was not ripe for eating until August 23. These differences may be due to the differences in the two seasons, for in 1895 the late summer was hot and dry and this year it was cold and wet; but one would not expect that season would make so great comparative difference between any two varieties as we found between Abundance and Burbank.

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*These plums are now beginning to attract attention in Europe; and the following report comes from South Africa (E. Tidmarsh, in Rep. Grahamstown Botanic Gardens, 1895, 5): "The Japanese plums, although not quite equal in flavor to the best sorts grown in Europe, have valuable properties for this climate. For one thing, these varieties, so far as I have tried them, grow freely grafted on the peach. A number of the European sorts refuse to grow on the peach, and this is a drawback in two ways. First, the peach stock is, on the whole, best adapted to this climate, and secondly, it is a difficult matter to raise suitable plum stocks in this country."

Persons in the South should consult Bulletin 85, Alabama Exp. Sta., on "Japanese Plums," by F. S. Earle.

This report has had the benefit of notes made upon the early varieties by S. D. Willard, during the writer's absence.

ABUNDANCE.

The best known of the Japanese plums, although it is not yet clearly distinguished from some of its allies. We have two types of Abundance, one a very narrow grower with a small pointed early fruit and small leaves, which may be Babcock; the other a moderately spreading tree, with the type of fruit shown in Fig. 1, Bulletin 106, ripening a week or ten days later than the other, and having large leaves. This latter I have taken as the type of Abundance. We have trees propagated from the original Lovett stock of Abundance, but they have not yet borne. We shall hope to clear the matter up in our next report.

The Abundance is a good plum, considering its season (ripened with us this year about August 25, being about two weeks later than hitherto), beauty and productiveness. It must be thinned if good specimens are desired. It is also subject to fruit-rot. Its quality is fully equal to that of the Lombard.

BAILEY: see Chabot.

BERCKMANS.—Fig. 113.

(*True Sweet Botan*, at least mostly.)

The description in Bulletin 106 seems to be characteristic, except that I should designate the color upon the fruits this year as bright deep red rather than "dull deep red." It is a handsome plum, with a soft flesh, and of medium to good quality. Tree a spreading grower. Two weeks later than Abundance this year.

113. *Berckmans.*

BLOOD NO. 4.

This was indistinguishable from Satsuma with us this year. I suspect that Heikes is the same.

BURBANK.

Now too well known to need comment. The best single variety of Japanese plum yet thoroughly tested in this state. Ripe with us this year from the tenth to the middle of September.

BURBANK NO. 1: see Hunn.

CHABOT.—Fig. 114.

(*Bailey. Chase*, mostly. *Yellow Japan.*)

This plum certainly deserves all that we said for it in Bulletin 106 (under the name of Chase). The tree is a strong upright grower, productive, and the fruit is handsome, very firm, and of good quality. In general appearance the fruit is much like Burbank, but it is more pointed and from one to three weeks later; and the tree, which is an upright grower, is very different. This year, it ripened with us from September 15 to 25. There seem

114. *Chabot. (Known also as Bailey, Yellow Japan and Chase.)*

to be two things passing as Chase, the other one being an earlier plum and perhaps identical with Douglas. I can detect no difference between Chabot, Bailey, Chase and Yellow Japan, and the same also passes as Hattonkin; but Chabot, being the oldest name, must hold.

CHASE: see Chabot.

DOUGLAS.—See title-page illustration.

(*Sweet Botan*, of some. *Hattankio* of some.)

This is the plum which I called Munson in Bulletin 62, but which Price renamed Douglas (Bull. 32, Texas Exp. Sta.) because there was already a Munson plum, one of the natives, upon the lists. The fruit is medium to large, oblong, deep dark purple; flesh firm, quality good; freestone, or very nearly so. Tree upright and vigorous, making a rather close round head. Ripened with us this year a week ahead of Abundance. Looks like a promising early plum.

EARLIEST OF ALL.

(*Yosebe* of Bulletin 106.)

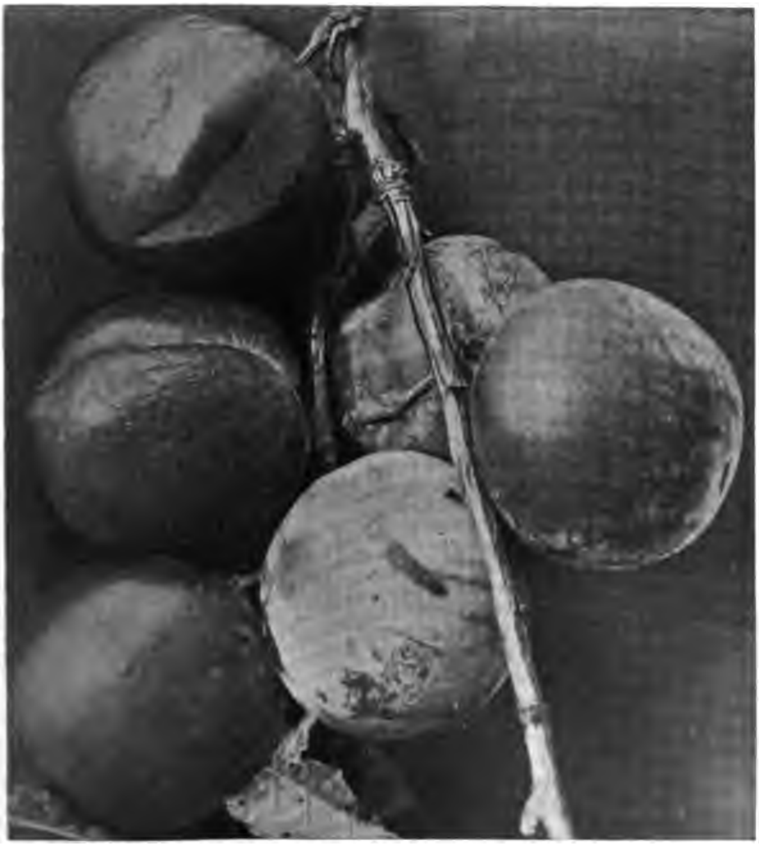
We shall drop the name Yosebe (which see), and take up Stark Bros.' name, Earliest of All, for the variety which we illustrated in Fig. 13, Bulletin 106. It is a strongly marked type, both in tree and fruit, and ripens here late in July. The description under Yosebe, in Bulletin 106, is characteristic. Fruit falls from the stem as soon as ripe, and can be gathered by shaking the plums onto sheets, or into a curculio catcher. No doubt useful for very early, but quality poor with us.

ENGRE.

Ripens with Earliest of All, but a half larger and quality distinctly better. Fruit flattened at both ends, the cavity broad and deep; color dark red, with many minute white specks, and a delicate bloom. Promising for very early.

GEORGESON.—Fig. 115.

Most of the plums passing as Hattankio belong here. It seems to be the only clear yellow Japanese plum known in this state, except Ogon. It assumes various forms. In Bulletin 106 we showed the flattened or rounded form. We now show a pointed form. I am convinced that these forms are only incidental variations of the same variety. It is a very solid golden yellow plum, of fair to good quality, and a long keeper. Ripe this year at Cornell September 15 to 20. A sprawling, forking grower, in form of top intermediate between Abundance and Burbank. The best yellow variety that I know. Kerr, another yellow variety, we have not fruited.



115. *Georgeson. The pointed type.*

HALE.—Figs. 116, 117.

With us the size and color of Burbank, and a week or so later.

116. *Hale.*

117. *Hale.*

A handsome globular, red and speckled plum, parting easily from the stem; flesh rather soft and juicy, of good quality and a peachy flavor, tending to be sour rather than sweet; tree (Fig. 117) moderately spreading, and a good grower, and evidently productive. Ripened with us this year from September 8 to 15. One of the most promising of the lesser known varieties.

HEIKES: see Blood No. 4.

HUNN.—Fig. 118.

(*Burbank No. 1.*)

118. *Hunn.* (*Burbank No. 1*).

Early, ripening just after Red June,—August 26, with us this year,—but keeping until September 3. A small plum, with a slight point as in Abundance, deep claret red with many minute golden dots; flesh thin and juicy, sweet and of medium quality; cling. Fruiting on Lombard; apparently productive and of upright habit. It may deserve a place among the early plums.

LOUISIANA.—Fig. 119.

(*Normand No. 15.*)

Tree a spreading and rather weak and slender grower, with foliage and spray very. strongly suggesting hybridity with the Wild Goose type of plum. Plum green in color even when fully ripe, dotted with light specks and marked with a faint and dull red blush in the sun; medium size, pointed or heart-like; flesh juicy and sweet at the center while it is still hard and rind-like near the exterior; fruits running very uneven in size and shape, some of the specimens on our tree being much misshapen (See Fig. 119). A curious fruit, in some respects suggesting Kelsey. Falls from the tree very early. Perfectly hardy with us thus far. Mr. Normand says that it is a "seedling of a Japanese crossed with a native plum."

MARU.

See description in Bulletin 106. It was a week or too later than Abundance with us this year. Tree upright-spreading, a good grower, with rather small leaves. Handsome, but rather small, and quality poor.

119. *Louisiana.* (*Normand No. 15*).

NORMAND.

Described as a very early somewhat conical yellow freestone, and specimens of fruit which I have had from Normand, the importer and introducer, answer the description. As fruited with us this year on Lombard stock, cions from Normand, it is a midseason clingstone and is indistinguishable from Georgeson. Ripe with us in 1897, Sept. 15 to 20. It remains to be determined whether there are two varieties passing under one name, or whether the same variety behaves differently under different conditions.

OGON.

A handsome clear yellow freestone plum, already well known, and fully described in Bulletins 62 and 106, and illustrated in the former. It is very early, ripening at Cornell this year about August 10. It is excellent for canning. The Ogon is generally regarded as a shy bearer, but our little trees were loaded this year. The fruit often cracks badly on the tree. The tree is an upright-spreading strong grower, with very large leaves which did not suffer from fungus.

RED JUNE.

Surely an excellent plum, maintaining the high character—for earliness, beauty and productiveness—which we gave it two years ago. The quality is not so good as that of the Burbank or Chabot. At Cornell this year, trees upon hard clay land ripened their fruits twelve days later than trees upon gravelly loam.

RED NAGATE.

I think that this name will have to be given up. It is most commonly applied to the variety which is now properly known as Red June, but we have Chabot under the same name.

SATSUMA.

One of the best marked of all Japanese plums, the fruit being dark dull red and the flesh blood-red. It is late, ripening from the middle to the last of September this year. The color of the fruit is against it for a general market plum, but its keeping qualities, and excellence for culinary uses, make it worth a place in the orchard. The quality is austere until fully ripe, when the fruit becomes fairly sweet. Tree a vigorous spreading-upright grower. Fairly productive with us, but reported as unproductive by others.

STRAWBERRY.

A small fruit, flattened upon the ends, with a broad and deep cavity, light red, meaty flesh, quality good, with flavor of domestica plums. Ripe here the very last of July in 1897. Tree strong, upright-spreading, with large foliage. This variety affords an excellent illustration of the various behaviors of Japanese plums. The tree was sent us by Stark Bros., who named it, but finding it not productive and not so good as Earliest of All, they discarded it. Yet at Cornell this year it was a good plum. It is evidently the same as Uchi-Beni, Ura-Beni, and is the Honsmomo of some.

120. *Wickson.*

UCHI-BENI AND URA-BENI:—see Strawberry.

WASSU.

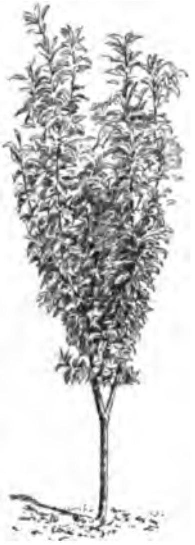
In both tree and fruit indistinguishable from Burbank. Tree from Normand, the introducer.

WICKSON.—Figs. 120, 121.

Although]we have this plum growing, it has not borne ; but since we have tested fruit of it grown by E. Smith & Sons, on

Seneca Lake, we give it place in this report, and the engraving (Fig. 120) is made from specimens of their growing. They write as follows: "Our experience with this plum is limited, but we are more than pleased with its habits and characteristic points. We find it a good grower, also very hardy, and the size of fruit superior to any of the Japanese plums. The quality we find a little under the average, but good enough to warrant us in planting. We have 100 trees of them, planted out one year ago in orchard form, and will set at least 500 more."

I am impressed with the Wickson and expect to find it an acquisition to New York. The fruit is very large, deep maroon-red, firm and long-keeping, with an aromatic almond-like quality, and deep, dull yellow, meaty flesh. The tree has been perfectly hardy with us. It has the habit of Prunus Simonii (Fig. 121), being the narrowest grower of all the Japanese plums which we have tested. Its habit suggests that Prunus Simonii entered into its parentage, but Mr. Burbank, the originator, says that it was grown from Burbank seed which was fertilized by Kelsey pollen.


121. *Wickson.*

WILLARD.

We have no new report to make upon this variety. (See Bulletin 106). Its only merit is earliness. The quality is very poor. It is a very strong, tall grower, but shed its leaves early with us this year.

YOSEBE OR YOSOBE.

We shall discard this name. The variety which we described and figured under this name in Bulletin 106 we shall hereafter call Earliest of All (which see). The name seems to be applied to a number of varieties, no one of which has any definite right to it. We have Satsuma under the name of Yosobe.

Correspondents are asking what varieties of Japanese plums I recommend. In reply I will say that I never recommend varieties of any fruit for anyone to plant. The merit of a variety must be measured by the uses to which it is to be applied and by the tastes of the planter, quite as much as by its intrinsic characters. The correspondent rarely specifies whether he wants a red plum or a yellow one, an early or a late, for dessert or for market. It is like asking a man at a distance what fence the questioner shall put in his back lot, without saying whether it is to be a pig fence, hen fence, sheep fence, cow fence, or a fence merely to mark off his premises from his neighbor's. I can state what varieties I might plant for myself, but my selection might not be such as would please my neighbor. For myself, I should still adhere to my list of four varieties of two years ago,—Red June, Abundance, Burbank, Chabot. I should place as second choice Douglas, Berckmans, Satsuma, Hale and Wickson and should expect that the last two would rise, upon further acquaintance, to a place in the first rank. If I wanted a yellow plum, I should take Georgeson, with Ogon for early. If I wanted the earliest varieties, without respect to size or quality, I should choose Berger, Engre, Earliest of All and Willard.

L. H. BAILEY.

Bulletin 140. **November, 1897.**
Cornell University Agricultural Experiment Station.
ITHACA, N. Y.

Second Report on Potato Culture

By I. P. ROBERTS and L. A. CLINTON.

PUBLISHED BY THE UNIVERSITY,
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Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

BULLETINS OF 1897.

124. The Pistol-Case-Bearer in Western New York.
125. A Disease of Currant Canes.
126. The Currant-Stem Girdler and the Raspberry-Cane Maggot.
127. A Second Account of Sweet Peas.
128. A Talk about Dahlias.
129. How to Conduct Field Experiments with Fertilizers.
130. Potato Culture.
131. Notes upon Plums for Western New York.
132. Notes upon Celery.
133. The Army-worm in New York.
134. Strawberries under Glass.
135. Forage Crops.
136. Chrysanthemums.
137. Agricultural Extension Work, sketch of its Origin and Progress.
138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.

POWDERED SOAP AS A CAUSE OF DEATH AMONG SWILL-FED HOGS.

It is a common experience of those who are engaged in the investigation of animal diseases to occasionally find outbreaks of a peculiar nature among swill-fed hogs. By these are meant herds of greater or less size, usually kept near or within the outskirts of our villages or small cities, and which are fed upon the kitchen refuse, often including the dish water, collected from hotels, boarding houses and private dwellings. The cause of death in these outbreaks is, in this state, at least, usually attributed to hog cholera. The basis for this popular diagnosis seems to be in the similarity of certain of the symptoms manifested by these animals to those of hog cholera, such, for example, as diarrhœa and partial paralysis and the fact that a majority of those attacked die. The course of the disease is irregular, deaths occurring in from a few hours to several days after the symptoms appear.

During the past year I have had occasion to make investigations into the nature of several of these outbreaks of a supposedly infectious disease. In a few of these epizoötics hog cholera or swine plague was easily demonstrated. In certain others, however, these or other infectious diseases could not be found. The animals were usually fed the kitchen slops collected from hotels and boarding houses. The tissue changes in the animals examined were atypical of any known disease and notwithstanding the bacteriological examinations which were made, together with animal inoculations with pieces of the diseased organs, the cause of death remained undetermined. The post mortem examinations showed in nearly all of these animals enlarged and dark colored lymphatic glands, especially those of the mesentery. The blood vessels of the mesentery were very much distended with blood. The liver and kidneys were usually not affected but occasionally these organs were involved. Where there had been marked nervous symptoms the brain was much congested. Occasionally the lungs contained areas of collapse. The intestines were, as a rule, pale and the mucous membrane seemed to be abnormally shiny.

The negative outcome of these investigations suggested that possibly our methods had been faulty or that some unknown conditions existed which had obscured the cause of death, and that after all the popular diagnosis of an infectious disease was right. Against this theory was the fact that the disease did not spread from the affected herds to others, although. as a rule, precautions were not taken to prevent its dissemination and in some instances the neighboring herds were most favorably situated for contracting the disease if it had been contagious. In certain of the outbreaks the exceedingly filthy condition in which the pens and yards were kept suggested, in the absence of a knowledge of definite, specific agents, that the animals had died as a result of their unsanitary surroundings and unwholesome food, a hypothesis which in some instances is still entertained as being highly probable. However, we were still confronted with the problem that in many outbreaks neither a specific infectious disease could be found nor the exciting cause of death pointed out.

Although it was apparent that the cause of the deaths was to be found in the food, the feeders of this kind of swill failed to see why they should discontinue its use. Naturally they felt that if we could not find or demonstrate the presence of the destructive agent in the swill the cause of death must be something else, probably hog cholera, for thousands of hogs are annually raised upon this kind of food. Further, the plea that such garbage was not a suitable or even wholesome food for their animals availed nothing for the reply was, that usually their pigs thrived upon it.

Early in the summer, in conversation on this subject with Mr. W. F. Davey, an enterprising farmer living near Brewerton, N. Y., he related the circumstances concerning an outbreak of this kind in which he had traced the cause of the trouble to the soap used in washing the dishes. The swill, including the dish water, was collected from three small hotels and fed to a herd of swine. In a short time the animals began to sicken and many of them died.

Upon inquiry it was found that in the hotels large quantities of powdered soap were used in washing the dishes. This was stopped and no more animals died. Later in the season Dr. J. A. McCrank, of Plattsburg, told me of an outbreak of an apparently infectious disease among swine which had come under his observation and in which he could not make a positive diagnosis. In the investigation of its cause be found that the hogs were being fed the swill, including the dish water, from a hotel. Upon inquiry he found that powdered soap was being used in large quantities. The swill from this place was stopped and the disease disappeared.

In following up the line of inquiry which these experiences suggested, it was found that there is among the more enterprising farmers, a quite general belief that these soaps, when given in considerable quantities, are injurious and even fatal to hogs. The consensus of opinion on this subject together with the more definite observations of Mr. Davey and Dr. McCrank appeared to be so conclusive that it seemed important to determine by careful experiment to what extent, if at all, powdered soaps can be considered as the cause of death in this class of outbreaks. To this end the experiment about to be described was carried out. It shows that when certain of the powdered soaps sold in the market are present in the food in relatively large quantities a considerable percentage of the animals will sicken and many of them will die. When, however, the soaps are added to the food in small quantities (a dessert spoonful in the food for three pigs, twice daily) no bad effects seem to follow. The cause of death when it does occur is probably due, as shown by the chemical analyses, to the free alkali, sodium carbonate or washing soda, which they contain.

EXPERIMENT IN FEEDING POWDERED SOAPS TO PIGS.

In the experiment three of the commonly used powdered soaps were selected. They are here designated as soaps A, B and C. Nine pigs weighing about 20 pounds each were taken. They were given their regular food, grain mixed in water and some separator milk. To this was added a definite quantity of the soaps which were dissolved and thoroughly mixed in the food twice daily.

Soap A.

July 10. Pigs Nos. 1, 2 and 3 were placed in pen No. 1. They were given, night and morning, regular rations as previously described to which were added 2 ounces of soap A.

July 14. Pigs well. Quantity of soap given increased to 4 ounces.

July 18. Pig No. 1 has profuse diarrhœa, others well.

July 20. Pig No. 1 has diarrhœa, at times it runs about the pen in apparently a dazed condition.

July 24. Pigs Nos. 1 and 2 have bad diarrhœa. Quantity of soap given reduced to 1 ounce.

Aug. 1. Pigs appear to be well.

Aug. 7. Quantity of soap increased to 5 ounces

Aug. 8. Pigs sick, all have diarrhœa, do not eat. Have some difficulty in walking.

Aug. 9. Pigs appear to be no better.

Aug. 11. Pigs still sick. Have eaten very little. Soap stopped.

Aug. 12. Pigs slightly better.

Aug. 15. The condition of the pigs is much improved.

Aug. 18. Animals apparently well.

The feeding of this soap was repeated on these animals some weeks later with a similar result.

Soap B.

July 10. Pigs Nos. 4, 5 and 6 were placed in pen No. 2. They were fed the regular rations to which were added, morning and evening, 2 ounces of soap B.

July 14. Pig No. 4 has a bad diarrhœa. Others well. Quantity of soap given increased to 4 ounces.

July 15. All three have a diarrhœa.

July 19. Pig No. 4 found dead. No. 5 very sick, unable to stand, refuses food.

July 20. Pig No. 5 can not stand, limbs constantly jerking. There seems to be paralysis. It dies late in the afternoon. Pig No. 6 has suffered from diarrhœa but otherwise seems to be well although it eats very little. Quantity of soap reduced to ½ ounce.

July 22. Pig No. 6 better.

Aug. 1. Pig No. 6 much improved. Soap discontinued.

SOAP C.

July 10. Pigs Nos. 7, 8 and 9 were placed in pen No. 3. They were fed the same as the others. Night and morning 2 ounces of soap C were mixed with their food.

July 13. All the pigs have diarrhœa, eat very little.

July 14. Quantity of soap reduced to 1 ounce.

July 16. Pigs very sick. Eat very little, head jerks constantly, limbs tremble, temperature 103.5, 104, 103.8° F.

July 18. Pig No. 7 dies suddenly to-day. Others still sick. No. 8 has much difficulty in standing. Lies with feet extended. Legs and head are constantly jerking. No. 9 has diarrhœa, eats little but otherwise appears to be well.

July 19. Pig No. 8 found dead this morning. No. 9 seems to be better.

July 20. Pig No. 9 eats heartily. Appears to be quite well.

Three other pigs, Nos. 10, 11 and 12 from the same lot were placed in pen No. 3 with pig No. 9. They were given ½ ounce of soap C thoroughly mixed with their food twice daily.

July 25. Pigs apparently well.

Aug. 1. Pigs apparently well.

Aug. 17. Pigs apparently well. The quantity of soap increased to 4 ounces at each feeding.

Aug. 18. Pig No. 10 sick.

Aug. 20. Pigs all sick, refuse food. They ate sparingly of some corn given them.

Aug. 21. No appreciable change.

Aug. 23. Pig No. 10 very sick. The muscles of the head and legs constantly jerking. Eats very little of the regular food but partakes sparingly of corn.

Aug. 25. No change.

Aug. 27. Pigs very sick, have refused food containing soap for two days. Eat sparingly of corn. Soap discontinued.

The pigs which recovered from the immediate effect of the soap did not become thrifty for some weeks. It was late in September before they began to show signs of growth.

POST MORTEM EXAMINATION.

Pig No. 4. The skin over the ventral part of the body and between the thighs of a pinkish color. Kidneys very pale. Spleen normal. The blood vessels of the mesentery much congested. The mesenteric glands enlarged and oedematous. Many of them are congested. Areas of the mucous membrane of the intestines especially the ileum, were of a dark reddish color. The lungs and heart were not changed. The brain was deeply congested.

Pig No. 5. This pig showed lesions very similar to those exhibited by No. 4. The essential difference was an increase in the intestinal congestion.

Pig. No. 7. The skin between the thighs and about the nose was of a bright pinkish color. The liver was small, exceedingly firm and friable. The mesenteric blood vessels were injected and the mesenteric glands were enlarged and oedematous and many of them deeply reddened. A few were hemorrhagic. Spleen normal. The cortex of the kidneys very pale but the papillae were abnormally dark. The mucous membrane of the intestines was congested in a few irregular areas. The mucosa of the stomach covered with a thick layer of mucus. The heart and lungs were normal in appearance. The brain was very much congested.

Pig No. 8. The tissue changes in this animal were similar to those found in pig No. 7 with the exception that the kidneys were much congested.

A careful bacteriological examination was made of the liver, spleen, kidneys and blood of each animal that died. In nearly every instance (all but two) the tubes of culture media (agar and bouillon) inoculated remained clear. The two exceptions contained saprophytic bacteria and were probably contaminations from the air. This examination shows that the alkali had not favored the migration of the bacteria from the intestines to the various organs of the body.

In order to check the results, several pigs from the same litters as those used in the experiment were kept, in adjacent pens, and given the same kind of food. They all remained well. This fact in addition to the negative results from the bacteriological examination, and the peculiar nature of the lesions are sufficient evidence that the sickness and the fatalities among the pigs in the experiment were due to the soaps administered.

It is important to note that the lesions found in the pigs which died in the experiment were similar to those found in the pigs in certain of the outbreaks mentioned among swill-fed hogs. Considering the facts as they appear, it seems highly probable that the cause of death of the animals in certain of the outbreaks mentioned was the presence of the free alkali in the swill. This hypothesis is supported by the experiences of Mr. Davey and Dr. McCrank.

CHEMICAL ANALYSIS OF THE SOAP POWDERS USED.

In order to ascertain the chemical nature of these soaps they were submitted to Mr. Geo. W. Cavanaugh, Assistant Chemist of the Agricultural Experiment Station for analysis. The following report was received :

"The soap powders used in the above experiment are mixtures of ordinary hard soap that has been powdered or in some way reduced to a fine condition, and sodium carbonate. Sodium carbonate is known in commerce, as Sal Soda, Washing Soda or Soda. In water it forms a caustic solution which is the lye used in making the old-fashioned hard soaps.

ANALYSIS.

Soap A........49.60 per cent.
Soap B........55.42 per cent.
Soap C........55.54 per cent.

(Signed) GEO. W. CAVANAUGH, Asst. Chemist."

A careful inquiry has been made to ascertain the quantity of these soaps commonly used in washing dishes. This has revealed the fact that while the amount used by different individuals varies, the quantity is large, usually far in excess of the amount prescribed by the manufacturers. Thus I have been told, by thoroughly reliable people, of dish washers who would use one-third of a box in cleansing the dishes after a single meal. While this is extreme, it is said not to infrequently happen, and it is easy to understand that the swill from these kitchens would contain far more of the alkali than we found necessary to produce fatal results. Should such excess in the use of these cleansing agents be indulged in for several days in succession, we have, in the light of the foregoing experiment, a cause for many fatalities among the hogs fed upon the dish water.

In view of this danger it seems better to abandon altogether the habit of giving dish water to hogs. Although the feeding of garbage is generally condemned, the scraps of vegetables and table refuse could, perhaps, if properly collected be used with safety. But certainly pure water is a much more wholesome drink, even for swine, than dirty dish water. When the subject of "swill feeding" as a business is studied and the conditions as they exist are understood the wonder is, not that some of the hogs die, but rather, that any of them live.

It is not presumed that the poisoning by carbonate of sodium, is the only cause of death among swill-fed hogs. Other destructive agencies are liable to be found in the decomposing garbage. The results of the investigation which the necessity of good farm hygiene demands will very likely disclose the specific nature of many of them. Another fact worthy of consideration is that the investigation of the last year shows that nearly all of the outbreaks of hog cholera and swine plague which came to our attention started among herds of swine fed upon garbage and swill collected from the sources above mentioned. This is significant and it points to the undesirableness of feeding garbage to animals. In fact if the total losses it occasions are counted, it is questionable if anything is gained in this attempt to save waste products. It is stated in the official reports of the U. S. Department of Agriculture that in 1896 12 per cent. of the hogs in this country (which amounts to 5,440,176) died from disease.

Again it has long been recognized that the feeding of garbage to hogs furnishes one of the most favorable channels for the introduction of hog cholera and swine plague bacteria. As a rule, wherever we find hogs in clean, well ventilated pens and fed upon wholesome food we find thrift and health, and conversely, where these animals are surrounded with disgusting filth and fed upon decomposing slops or other unwholesome food we expect to and often do find disease.

It is unfortunately becoming a too prevalent habit among our farmers to assume, as soon as one or two pigs die that some infectious disease, such as hog cholera, is among them. It is further most unfortunate that they frequently entertain the fatalistic notion that a remedy is beyond their reach. Fully 25 per cent of the outbreaks of reported hog cholera which we have investigated during the past year have not been hog cholera or any other known infectious disease. While it is true, that when hog cholera becomes well established in a herd there is great danger that the majority of the animals will die, it is equally true that if the disease is not a genuinely infectious one that a majority of the animals can, by proper treatment, be saved. When a pig sickens and dies the thing to do is to examine, or have it carefully examined, to find out if possible what the cause of death is, in order that the best methods known for preventing the further spread of the disease may be promptly adopted.

If the examination shows the disease to be hog cholera, swine plague or any other infectious disease like anthrax or tuberculosis the as yet uninfected and apparently well animals should be placed in other pens and the old ones disinfected. The animals should be given easily digested and nourishing food, plenty of sunlight and pure air. If others should become affected, the well ones should again be separated from the sick. The channel or way by which the specific cause of the disease got into the herd should be diligently sought for. As the most common way is through the food it is always a safe precaution to change the diet.

It is certainly not desirable to acquire the reputation of having an infectious disease among one's animals when the real trouble is due to poor hygiene, to some irregularity in their care, or to an accidental poisoning.

If the diagnosis can not be positively made it is best to put the apparently well hogs in a separate pen, provide them with good ventilation, wholesome food and cleanliness. *It is important that the food should be changed.* By carefully observing the method of *strict isolation*, disinfection, healthful surroundings and nourishing diet many epizootics of infectious diseases have been checked and it is safe to presume that if such precautions were rigidly adhered to nearly all of the losses now sustained from dietary causes would be saved. The observance of the rules necessary for the promotion of good health among mankind apply with equal force to the lower animals.

CONCLUSIONS.

From the foregoing the following conclusions seem to be warranted.

1. The greatest amount of loss sustained from swine diseases in this state is among hogs fed upon the swill collected from hotels, boarding houses, and other large institutions.

2. The cause of death in certain outbreaks of disease among swill-fed hogs is the direct poisoning of the animals by the excess of free alkali (washing soda) in the swill. These alkalies come from the powdered soaps used in washing dishes.

3. It appears that small quantities of the powdered soaps do not produce immediate bad results. It is presumable that they can be used in quantities sufficient for the needs of cleanliness with perfect safety, but owing to the danger involved in their use it is safer not to give the water containing them to animals.

4. In addition to the unwholesomeness of garbage and kitchen slops for animal food, and in addition to the losses sustained from the immediate effect of such kinds of food, hogs fed upon it are very liable to contract specific infectious diseases such as hog cholera, swine plague and tuberculosis.

5. The enormous amount of loss among garbage fed hogs, which in this state alone aggregates thousands of dollars annually, suggests the desirability of urging the discontinuing of the practice of collecting swill for such purposes. Certainly if the refuse material is to be used for feeding swine it should be collected and fed while fresh and sweet. When possible, it should be kept dry, and by all means free from alkaline dish water. It is advisable to cook all kitchen or table refuse before feeding in order to remove the danger of infection from specific diseases. The only suitable channel for the disposal of dish water is the sewer.

New York State Veterinary College,
Cornell University, Ithaca, N. Y., Oct. 20th, 1897.

Bulletin 142. **January, 1898.**

Cornell University Agricultural Experiment Station.
ITHACA, N. Y.
ENTOMOLOGICAL DIVISION.

The Codling-Moth.

(*Picture from Lodeman's "The Spraying of Plants," by permission of The Macmillan Co.*)

By M. V. SLINGERLAND.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
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142. The Codling-Moth.

THE CODLING-MOTH.

Carpocapsa pomonella Linn.

Order LEPIDOPTERA; family GRAPHOLITHIDÆ.

Almost every lover of fruits has seen a "wormy apple," and most people understand that, as our little two-year-old daughter puts it, "a naughty old worm did it." The time is soon coming when these little observers of nature will not be content with this meagre information, and fathers and mothers will be called upon to tell more of the story of the life of this "naughty old worm." How few of us know this story!

This apple-worm is one of the most serious drawbacks to the profitable growing of apples by the average fruit-grower. From one-fourth to one-half of the apple-crop in the United States is usually ruined annually by this insect; it thus exacts millions of dollars of tribute yearly from our fruit-growers. As many of our more progressive orchardists have already learned, the number of wormy fruits can be largely reduced by the intelligent application of modern methods. In spite of the fact that this insect usually causes a greater monetary loss to the apple-grower than all the other insect foes of the apple combined, yet it can be often more easily controlled than the apple-borer, the canker-worms, and several other orchard pests. We wish that every apple-grower could be induced to read, from Nature's book if possible, the life-story of this insect, and then put to practical use the knowledge thus obtained. For we are hopeful that then it would not be necessary to look over a bushel of apples in our city markets to find half a dozen that were not wormy; and besides the apple-grower would then be prepared to introduce a very interesting bit of nature-study into the home whenever the little ones chanced upon the work of the "naughty old worm." It has come to be a well-established fact in our experience among fruit-growers, that those who combat their insect foes with the least trouble, the most successfully, and get the most fun out of it—they are the ones who like Hiawatha have :

"Learned their names and all their secrets,
How they built their nests in summer,
Where they hide themselves in winter,
Talked with them when'er he met them."*

Naturally much has been written about an insect of such great economic importance, and yet the literature embraces but comparatively few approximately exhaustive and comprehensive accounts of it ; none of these are now easily accessible to the fruit-grower. By far the best account, written by Dr. L. O. Howard, was published in 1888, and no similar attempt has been made by American writers since. Although many reports, comprising thousands of pages of printed matter, have been made on the insects of New York State, it is a surprising fact that everything therein pertaining to this most important of all orchard pests would occupy little more than half a dozen printed pages. We began a critical study of the insect in the spring of 1896, and for nearly two years have devoted much time to careful observations of its habits in all stages. Considerable time has also been spent in ransacking all of the foreign, as well as American, literature that could be bought or borrowed ; several interesting facts have been gleaned from this search through many quaint and musty records which make up the history of this insect.

The above facts, we believe, fully warrant the somewhat exhaustive discussion of this pest which follows.

SOME GENERAL HISTORICAL NOTES.

It is said that Cato speaks of "wormy apples" in his treatise on Agriculture, written nearly 200 years before the Christian era. In the first century

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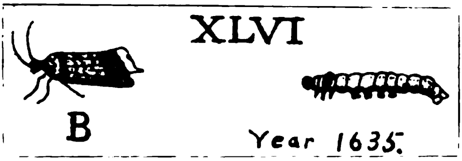
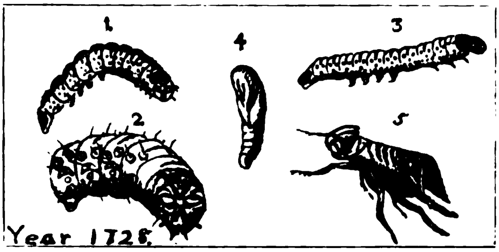
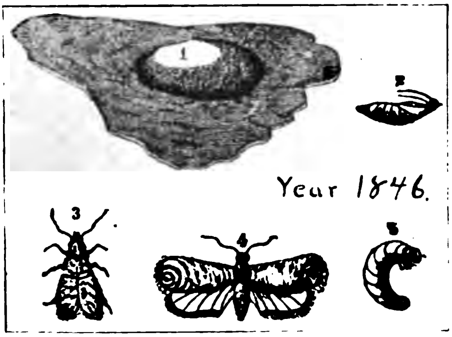
* As some inquisitive mind may wonder why it is necessary that man should be tormented with this little worm whose palace is the wormy apple, we submit the only attempt at an explanation that we have seen : "Or were they created, solitary preachers on each little globe of fruit, which falls like manna from above, to teach us some great moral lesson ? Come they into our very faces to remind us how 'dearly we pay for the primal fall ?' Do they inhabit the finest specimens of that fruit by which our first mother was tempted, in order to bid us taste the viands of Eden, and make us feel that 'the trail of the serpent hangs over them all ?'"

First Account of the Codling-Moth ever Published.—"These grubs have their origin in the interior of the sugar-pears, where they have their home and find all their necessary food. It disposes itself for transformation on the 3rd of August, and on the 2d of July of the following year, the moth is so far advanced as is indicated at B; thus it has lain as if dead in its process of transformation for eleven months. I name it from its food the *Pear-eater.*" (Translated from Goedaerdt's quaint Dutch volume, *Metamorphosis Naturalis.*)



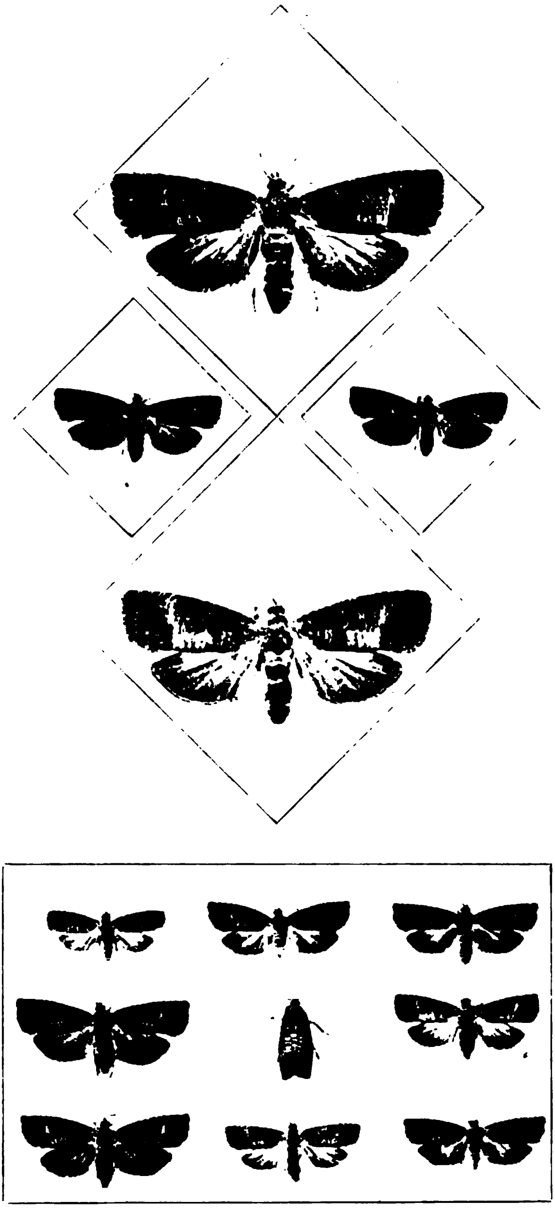


A GROTESQUE OLD GERMAN PICTURE. (FROM FRISCH.)



THE FIRST AMERICAN PICTURE.

126.—*Some historical pictures of the Codling-Moth.*



128.—*Pictures of the codling-moth, showing its variations. All natural size, except the two large ones, which are enlarged twice.*

A. D., both Columella and Pliny doubtless refer to this insect in their writings. Pliny says: "The fruits themselves, independently of the tree, are very much worm-eaten in some years, the apple, pear, medler, and pomegranate for instance." While the apple-growers of these ancient times were doubtless familiar with the work of this worm, yet the real history of the insect itself apparently begins in 1635, or almost with the beginning of purely entomological literature. A translation, with a reproduction of the pictures, of this first quaint Dutch account is given in figure 126. Nearly a century seems to have elapsed before we again find the insect discussed by entomologists. In 1728, Frisch, a German writer, gave us the first detailed descriptions of the insect; his grotesque pictures of the different stages are reproduced in figure 126. Before the middle of the 18th century, two other especially noteworthy accounts were published. In 1736, Reaumur, a Frenchman, added some accurate details, with good figures, of its habits in the fruit, and in preparing for transformation. Ten years later, Roesel, a German writer, devoted several pages of his wonderfully interesting "Insect Recreations" to a very good account of the habits and life of the insect based upon original observations; the hand-painted pictures illustrating this have never been excelled in color since. The next year, 1747, apparently the first English account, by Wilkes, appeared. He compiled briefly from Roesel, but rendered his account especially noteworthy since he then gave to the insect the common name by which it is to-day recognized by all the English-speaking peoples.

During the next century and a quarter much was written of the insect in Europe, and considerable was added to our knowledge of some of the details of its habits and life. The most noteworthy German discussions during this period, from 1750 to 1875, were those of Schmidberger, Ratzeburg and Nördlinger. The excellent discussions by "Rusticus" (1833) and by Westwood (1838) still remain the best in the English literature. Among the best discussions in the French literature are those of Goreau (1861) and Boisduval (1867)

Although the insect had been introduced into America many years before (its introduction and spread in America is discussed later on) it seems to have been first noticed in American literature in 1819. Mr. Joseph Tufts, of Charlestown, Mass., then published an account of rearing a moth, instead of the plum curculio, which had been previously thought to be the sole cause of wormy apples in America. Thatcher had made the same discovery when he wrote the second edition of his "American Orchardist" in 1825. This is apparently the first notice of the insect in any horticultural book, and although Europeans had been writing of it for nearly 200 years, it is a curious fact that, so far as we can glean from the literature, it remained for this American writer to make the first suggestion for controlling the insect. Apparently it was not realized until 1832, when Dr. Harris called attention to the fact, that the insect which caused wormy apples in America was the same as the well-known European insect. Only two noteworthy discussions of the insect appeared in American literature during the next thirty years. In 1841, Dr. Harris gave a very good account in his "Insects of Massachusetts;" and in 1846, Miss Morris published in the *American Agriculturist* some original observations, accompanied by the first American picture of the insect. This picture is reproduced in figure 126.

The American literature of this pest since 1864 is doubtless nearly as voluminous as that of all other countries combined. During this period the following Americans have made notable additions to our knowledge of the insect and how to combat it: Trimble (1865), Walsh (1868), Riley (1863, 1873), Le Baron (1873), Cook (1875, 1888), Cooke (1881), Chapin (1883), Atkins (1884), Goff (1886), Forbes (1886, 1887), Wickson (1887), Howard (1888), Gillette (1889, 1891), Popenoe (1889), Washburn (1891, 1893), Koebele (1890), Munson (1892), Lodeman (1892, 1893), Marlatt (1894, 1895), Smith (1894, 1897) and Card (1897). The best and most comprehensive discussions of the insect are those by Le Baron, Cook (1875), Cooke (1883), Howard (1888), Gillette (1891) and Washburn (1893).

GEOGRAPHICAL DISTRIBUTION OF THE INSECT.

The native home of this insect, like that of its principal food, the apple, was doubtless southeastern Europe. It is now a cosmopolitan pest, occurring in nearly every corner of the globe where apples are cultivated. It is especially destructive in Europe, the United States and Canada and in the English colonies of South Africa, Australia, Tasmania and New Zealand. It is said to have been seen in Victoria about 1855, in Tasmania at least as early as 1861, in New Zealand in 1874, and in South Australia and South Africa about 1885. It has been a serious pest in Canada for many years, but it seems to have not yet gained a foothold in British Columbia. In 1871, Zeller reported having received it from Brazil.

Its introduction and spread in the United States.—It was probably introduced into the United States from Europe in packages containing apples or pears. Just when the insect arrived in America will doubtless never be known. It may not have been until about the middle of the last century, for we find no references to "wormy apples" until after the plum curculio began to be discussed in the literature. For many years the cause of wormy apples in America was thought to be the plum curculio. Apparently it was not until 1819, that this mistake was discovered by breeding a moth from the supposed grubs of the curculio.

At that time wormy apples and pears were common near Boston. By 1840, the insect had become a serious pest in the New England States and was common in central New York. A few hints here and there in the literature give us some idea of its westward progress. It is said to have been unknown in Illinois in 1849, and to have not invaded Iowa until about 1860. During the next decade its westward progress must have been rapid, for it reached Utah soon after 1870 and appeared in California in the spring of 1874.

The insect is now recognized as a pest in nearly every section of the United States where there are bearing apple-orchards.

How it is spread.—As the worm often goes into the barrel or other packing-case with the fruit when it is picked, and as it finds therein a suitable place to spin up and undergo its further transformations, it is thus often transported for longer or shorter distances. This is doubtless the principal method by which the insect has been distributed, whether from one state to another or from one continent to another. When these receptacles are emptied of their fruit at its destination, they are often thrown one side without a thought that adhering to the sides and tucked away in the cracks there may be a dozen or even a hundred of the little worms in their snug cocoons, only awating the proper season to develop into the parent insects, which usually have little trouble in finding a suitable place in which to start their progeny.

ESTIMATED LOSSES FROM ITS RAVAGES.

Evidently this insect has been noticeably destructive in orchards, that is, it has ranked as an insect pest, since the earliest times; for Pliny wrote in the first century of the Christian era that apples and pears "are very much worm-eaten in some years." Judging from recent reports, the percentage of wormy fruits is at the present time nearly as large in many parts of Europe as it is in America. Conservative estimates put the annual loss from its ravages, in all countries where it is noticeably destructive and but little is done to check it, at from 25 to 75 per cent of the crop of apples; but with pears the loss is usually considerably less. Where modern methods of combating the insect are practiced, this percentage is often reduced one-half or more.

We have seen but two estimates of how many dollars this pest may cost fruit-growers annually. In 1887, Professor Forbes, after making careful experiments and observations, and making all allowances for modifying circumstances, reached the conclusion that the annual loss due to the apple-worm in the state of Illinois must reach the enormous total of $2,375,000, or one-half the value of the average apple crop. In 1892, the insect is said to have caused a loss of $2,000,000 to the apple growers of Nebraska.

Through the kindness of the *American Agriculturist* in furnishing us with the statistics, we will hazard an estimate at the annual tribute which our New York apple-growers pay for the ravages of this pest The average annual crop of apples in New York now amounts to about 5,000,000 barrels; as $1.50 per barrel would seem a fair average valuation, the total valuation of the annual crop may be estimated at $7,500,000. Although many New York fruit-growers are fighting this insect with modern methods, we think that the wormy apples would constitute at least one-third of the total crop. That is, New York fruit-growers yearly furnish $2,500,000 worth of apples to feed this insect; and there must be added to this at least $500, 000 worth of pears (certainly a low estimate for New York) which the same insect renders worthless. This makes a tax of $3,000,000 which a single insect levies and collects each year from the fruit-growers of our state.

ITS FOOD.

The insect feeds mostly upon fruits, and is above all an apple pest. It has also worked in pears from the earliest times, in fact, it was first named a "pear-eater" in 1635. (See this quaint account in figure 126.) Sometimes the insect works in pears as freely as in apples, but usually the percentage of wormy pears is considerably less. Wild haws, crab apples, and quinces are also quite freely eaten by the worms. Sometimes the insect works in the stone fruits. In 1868, Saunders reported it as quite destructive to plums in Canada, and it has recently been found in plums in New Mexico. About 1870, it was found to have acquired a taste for peaches in this country, and a little later it was bred from apricots. In 1893, Koebele found it infesting cherries in California. It has also been found in Europe in nearly all of these fruits.

There are several European records of the occurrence of the insect in walnuts and oak-galls. These reports were carefully sifted by Dr. Howard in 1887, and the conclusion reached that the evidence was not sufficient to definitely prove that the insect does sometimes feed upon walnuts or oak-galls. We have seen no further conclusive evidence on this point. In 1869, Dr. Riley recorded having a specimen of the moth which had been bred from the sweetish pulp of a species of screw-bean (*Strombocarpa monoica*) which grows in pods, and which was obtained from the Rocky Mountains.* In 1894, Bruner of Nebraska reported that perhaps the insect fed upon the seed-buds of roses.

ITS NAME.

Popular name.—When the insect was first discussed in 1635, it was named the "pear-eater." It was next called the "fruit-worm in pears and apples" in 1728; and from this has come the common names, "apple and pear-worm or moth, fruit-worm, fruit-moth," and others, under which the insect is now discussed in nearly all publications except those in the English language. While the very appropriate name of "apple-worm" is also often used by English and American writers, they usually discuss the pest under the perhaps less suggestive name of "codling-moth."

This name was first given to the insect in 1747 by Wilkes, an English writer; as he figures a codling-tree (the name then applied to a kind of apple-tree), in connection with his account, this doubtless suggested the name. The word "codling" is doubtless a corruption of the old English word "querdlyng," meaning at first (in the 15th century) any immature or half-grown apple, then in the 17th century being applied to a variety suitable to be cooked while still unripe, but the peculiar codling-shape seems to have determined its modern application to certain varieties of apples. At the present time, most horticulturists and some entomologists are spelling the name "codlin;" and sometimes the form "coddling" appears. Neither of these forms or variations have any etymological evidence to support them, and the name of the insect should be spelled "codling-moth," as originally given in 1747.*

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*One instance is recorded where the insect apparently took an inclination to literature and mutilated some books to a considerable extent. Apples had been stored near a library and the worms upon leaving the fruit and seeking a place to transform, gnawed their way into some of the books and there spun their cocoons. We also encountered this literary habit of the insect when infested apples were left near books on the office table where this is being written.

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*The form "codlin" was used as early as 1715 in connection with a kind of apple, but seems not to have been used in speaking of the insect until a century or more later. Nearly all prominent horticulturists and most English and Australasian writers now use the form "codlin-moth," but nearly all American entomologists still spell it "codling-moth." While the shorter form thus has the sanction of good usage, its only excuse for existence, so far as we can learn from those who use it, is that it is shorter and thus saves time in writing. The shortening makes it a different word, both in form and pronunciation. The encyclopedias offer contradictory and unreliable evidence. The dictionaries are our most reliable sources of information on such questions, and although both forms are given in most of them, we find that "codlin" is considered by the Century Dictionary as practically obsolete, and by the Standard Dictionary is recognized simply as a variant. Still stronger evidence in favor of the incorrectness of "codlin" is the fact that the original word is made up of "cod" and the old English diminutive suffix "ling;" and it is manifestly an inexcusable violation of etymological rules to drop the "g" of the "ng" of this suffix, thus making practically a new word, simply for the sake of brevity in writing, not in speaking. The most reliable authorities on compounding words also use the hyphen in the name, thus, "codling-moth."

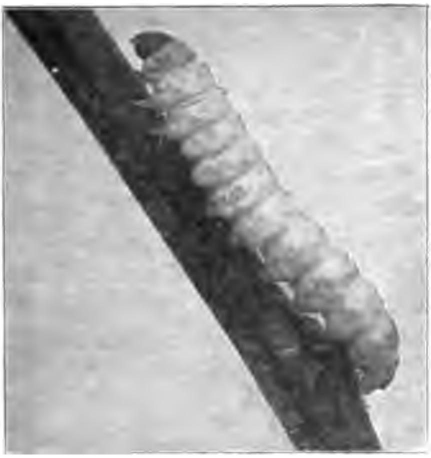
As to the form "coddling-moth," noted etymological authorities (the Century and Murray's New English Dictionaries) agree that there is doubtless no connection between the verb "coddle" and "codling," meaning an unripe apple; the resemblance is purely accidental, the verb appeared later, and there is no required precedent form of "coddling-apple."

Scientific name.—The name by which this insect is recognized by scientists the world over, was given to it by Linnaeus in 1758. This great naturalist named it *pomonella*, and his description of it consists of only six words: "Alis nebulosis postice macularubra aurea."[*]

As our knowledge of the world's insect fauna advanced, the generic position of this insect was changed from the *Tinea* of Linnaeus through *Pyralis*, *Tortrix*, etc., until now all scientists agree in calling it by the generic name (which corresponds somewhat to our sirname) of *Carpocapsa*, which was proposed in 1830. This name comes from two Greek words meaning, "I eat fruit greedily." The specific name comes from the Latin word for apple. The scientific name of the insect, *Carpocapsa pomonella*, thus aptly expresses its characteristic habits.

HOW THE INSECT LOOKS.

Who has not, in biting or cutting into an apple, unceremoniously disturbed a little flesh-colored caterpillar in its home, the familiar worm-eaten interior?[†] When full-grown, this apple-worm is about three-fourths of an inch long, and varies in color from whitish, through flesh-color, to sometimes quite a distinct pink. Some have thought that this variation in color may be due to the different varieties of apples infested. The gen-



127.—*The Apple-Worm, enlarged about three times.*

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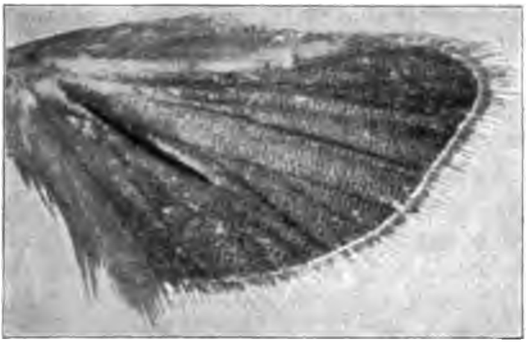
[*] In 1775, Fabricius gave it the name of *pomana*, and a year later it was named *pomonana* by Schiffenmüller. It is a curious and, to us, an unexplainable fact that nearly all continental European writers on economic entomology should still use this name, *pomonana*. The fact that the same insect was described and named by Linnaeus as *pomonella* eighteen years before, and thus has priority, seems never to have been questioned. Why *pomonana* should still be used seems a mystery.

[†] This is well shown in the picture used as a frontispiece.

eral characteristics of the worm are shown in the enlarged figure 127. It can always be distinguished from the grubs of the plum curculio, which are often found in apples, by the presence of distinct legs, three pairs of true legs and five pairs of false or pro-legs. The head is brown in color, and the first thoracic and anal segments each bear a similarly colored shield. The body bears a few short hairs arising from small, often indistinct, blackish spots. These piliferous spots are often very distinct on the young worms, as is shown in figure 132.

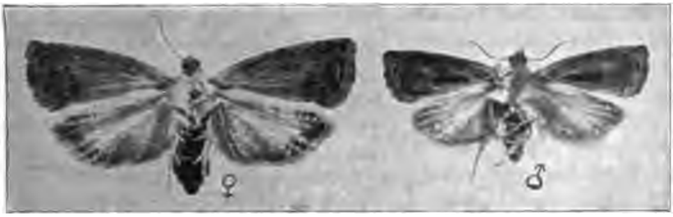
The adult insect or codling-moth.—If no mishap occurs, each of these little caterpillars just described develops into the adult insect—a moth. Although such an exceedingly common and important insect pest, there is doubtless not one fruit-grower in ten who has ever seen the parent insect—the moth. It is a beautiful little creature whose front wings, when seen at a little distance, have somewhat the appearance of brown watered silk; when closely examined, they will be seen to be crossed by numerous gray and brown lines of scales, scalloped something like the plumage of a bird. Near the hind angle of each front wing there is a large dark brown spot marked with streaks of bronze or gold The hind wings are of a lighter greyish-brown color, darker toward the outer margin. The pictures of this moth (all of which are natural size, except two which are twice natural size) in figure 128 give one but a faint idea of the artistic beauty of this pretty creature. An artist who once painted for us a picture of this moth thoroughly appreciated the beautiful coloring with which Nature has endowed it. As is shown in the lower group of figure 128, the moth varies considerably in size and general coloring; the moth in the center of this part of the figure is represented at rest and shows how nicely the markings on the front wings match when the wings are folded, thus giving the insect quite a different appearance. The peculiar coloring and especially the habits (discussed further on) of these pretty little moths largely explain why our fruit-growers are not familiar with the parents of one of their worst insect foes.

How the male and female moths may be distinguished.—There are at least two characteristics by which the sexes of the adult insect may be quite readily distinguished. One of these was discovered by Zeller in 1870, and is shown, much enlarged, in figure 129. It consists of a narrow pencil of rather long black hairs situated in a slight furrow on the upper surface of each hind wing ot the males only. Sometimes this distinguishing mark is not easily seen, except with a lens.



129.—*Hind wing of male moth, showing narrow black pencil of hairs, much enlarged.*

We have in our collection at the University over a hundred bred specimens of the codling-moth, and while separating the sexes of these by the aid of the character just mentioned, we accidentally discovered that the males bore another much more conspicuous, yet constant and peculiar mark. In figure 130 are shown a male (on the right) and a female moth, twice natural size, as seen from beneath. It requires but a glance to see that on the underside of each front wing in the male there is a distinct, narrow, elongate, blackish spot, which is entirely lacking on the female. The spots consist simply of a group of blackish scales. The spot extends nearly to the base of the wing, and is more distinct on some specimens, but in our experience it has always been distinct enough to render it an easy matter to distinguish the males at a glance, no lens being necessary.



130.—*Male (on the right) and female moth, twice natural size, as seen from beneath. Note characteristic black spots on front wings of male only.*

We cannot understand how this sexual marking could have escaped the notice of entomologists for a couple of centuries. Doubtless others have seen these spots, but we have not been able to find the slightest hint that they might be a sexual characteristic either in systematic or economic discussions of the insect.

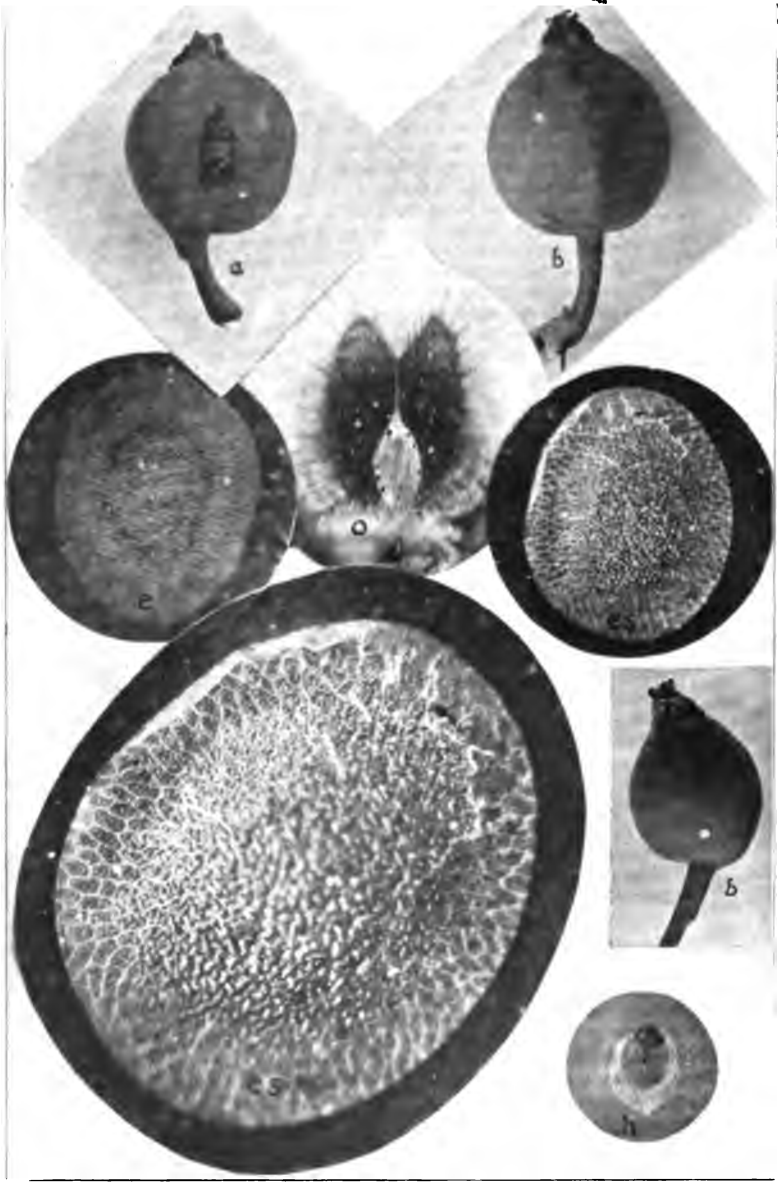
THE STORY OF THE LIFE OF THE CODLING-MOTH.

Perhaps the biography of no other insect pest has been written so often as that of the codling-moth. Begun by Goedaerdt in 1635, and considerably extended by Reaumur in 1736, it was fairly well understood by Roesel as early as 1746. Since then the insect has been studied under many varying conditions in nearly all climes, and naturally different observers have been able to add many interesting details in regard to variations in its habits and life-history. Yet there are many interesting things to be learned about this common insect pest before its complete biography can be written. Our story of its life which follows is the result of a critical study of all of the biographies available, supplemented by many personal observations on the insect in all its stages. This story may very properly begin with that stage in which life begins for the insect.

The Egg.

It is a curious and striking fact that it is only within the past few years that anything definite has been recorded about the egg itself, in which so common and important an insect pest begins its life. Recent observations in this connection have brought out some facts which are of vital importance to the fruit-grower.

Historical notes.—By whom or when the eggs were first seen, we have been unable to determine. In spite of the fact that nearly every account since Rœsel's in 1746, contains definite statements regarding where they are laid, and as early as 1855 we find it stated that they are said to be of a pale, yellowish-red color, yet there is no definite evidence to show that the eggs were ever seen on an apple before 1870, and perhaps not until nearly twenty years later. The eggs have often been taken from the body of the moth, and Riley's description of them as "tiny yellow eggs" (1869), and Fernald's brief description in Bull. 12 of Mass. Expt. Sta. (1891) were undoubtedly made from eggs thus obtained. If Cook saw numbers of the eggs, as he states, in 1874, *on* or *in* the calyx of the young fruit, it seems strange that he has never given us a hint as to how they looked, and that no other observer since has ever found them *on* or *in*, although sometimes *near* the calyx. In 1881, Cooke saw eggs which a codling-moth had deposited in a vial, and in 1882, Miss Walton states that some of the moths laid a lot of eggs in her cyanide bottle, but her description does not apply to any of the eggs we have ever seen.



131.—*Some pictures of the egg of the codling-moth; natural size on the apples at* a, b, b, *and enlarged at* e, es, es, h; o *shows the end of the ovipositor of the female.*

The eggs were undoubtedly seen on the fruit by Kœbele and Wier in California in 1889 (Insect Life, II., 84), and by Wight in New Zealand in 1891 (Insect Life, III., 394). But none of these writers tell us how the eggs looked. It is a notable fact that, after ravaging apple orchards for centuries and after undergoing the closest scrutiny by many competent observers, the first picture and accurate description of the egg should not have appeared in the literature until 1893. In 1892, Mr. F. L. Washburn made the first careful observations upon the eggs, and his results were published in 1893, in Bull. 25 from the Oregon Expt. Station. His picture of the egg is not quite accurate, but we cannot understand why such important observations should have been almost entirely overlooked by later writers. In 1895, the eggs were described and poorly figured by Gœthe in Germany. He built a cage over a small tree, and introducing some of the moths, soon got eggs and recorded their development. In 1896 the writer, and in 1897, Mr. F. W. Card in Nebraska, recorded further observations, quite at variance with the commonly accepted ideas regarding the egg-laying habits of this insect.

How the egg looks.—Fortunately we were able to get some life-like photographs of the eggs of the codling-moth and these are reproduced in figure 131. The small whitish spots on the apples at *a* and *b*, *b* in the figure represent the eggs natural size, just as they were laid on the fruit by the moth. At *e* is shown one of the eggs much magnified, and *es* and *es* are pictures of the egg-shell, greatly enlarged. These pictures give a good idea of the shape, size and general appearance of the egg. They have been aptly characterized as resembling a minute drop of milk adhering to the skin of the fruit.

The egg is a thin, scale-like object, not quite so large as the head of a common pin (it measures from .96 to .99 mm. by 1.17 to 1.32 mm.), and is of a semi-transparent, whitish color, often with a yellowish tinge, which is sometimes quite pronounced. Unless one has seen the eggs, they could not be readily discovered on an apple; those on the apples at *a* and *b*, *b* in the figure were unnaturally whitened to bring them out in the reproduction. After one has become familiar with the eggs, it is a comparatively easy matter to find them by turning the fruits around; when the light strikes the egg just right it can be quite readily seen. As the pictures in figure 131 show, the whole surface of the shell, when viewed under a microscope, is quite rough and is marked with an irregular net-work of fine ridges extending from the edge over about one-half of the surface, but not over all of the surface as represented in Washburn's picture.

Where and when the eggs are laid.—In the light of recent observations, it seems remarkable how the notion, that the eggs of this insect are laid *on* or *in* the so-called calyx or blossom-end of the fruit, has clung to the literature for nearly a century and a half.

Rœsel was apparently the first one to make any definite statement regarding oviposition. He said in 1746: "The female places her impregnated eggs singly either below at the stem-end or above at the blossom-end of the fruit." In 1833, "Rusticus" wrote that the moth lays its eggs "in the eyes, one only in each, by introducing its long ovipositor between the leaves of the calyx, which form a tent above it that effectually shields it from any casualty." In 1855, Nördlinger wrote that "according to some, the moth deposits its eggs upon the fruit itself, according to others, usually upon the calyx or between the calyx lobes or in the stem-cavity. Undoubtedly all of these views are correct." The fact that the worms do often enter at the blossom-end, and sometimes near the stem or even on the side of the fruit, was apparently the only foundation for the common notion that the eggs must have been laid at these points.

However, in 1889 and 1891, observers in California and New Zealand noticed that the eggs were laid almost anywhere else on the fruit than in or on the calyx; some were even seen on the stems of pears. In 1892, Washburn found the eggs "placed on both the sides and the top of the fruit." In the spring of 1896, we saw the egg of the codling-moth for the first time; a moth had been induced to lay it on an apple in one of our cages. A little later we had no trouble in finding many eggs in orchards. In confinement, we found that the moths laid their eggs almost anywhere it happened, on the sides of the cage, on the leaves or bark of branches placed in the cage, and sometimes several eggs were laid in a cluster, overlapping each other; Gœthe had a similar experience in Germany in 1895.

During the past two years we have seen hundreds of the eggs on apples in New York orchards and have never yet seen one *on* or *down in* between the calyx lobes on the so-called blossom-end. We have seen eggs *near* the calyx, in old curculio scars, near the stem, and have found what appeared to be codling-moth eggs even on the leaves of the tree. Most of the eggs we found were glued to the skin, apparently without much choice as to location, on the smooth surface of the fruit, as shown at *a* and *b*, *b* in figure 131.

During the past year Mr. Card has found the eggs in Nebraska. He states that "instead of being laid in the calyx, we find that the eggs are laid almost exclusively on the upper surface of the leaves, in the orchard, though in confinement they may be laid anywhere. They are usually found on leaves of a cluster associated with an apple."

In the light of these definite facts, the old stereotyped notion that the eggs are usually laid *in* the calyx, must be discarded. The eggs may be glued anywhere it happens to the surface of the fruit, to the stem, or even on the adjacent leaves. A glance at the ovipositor of the moth, represented at *o* in figure 131, shows that it is only adapted for laying eggs on the surface of the fruit or leaf. It is quite flat and hoof-like in appearance, and strongly beset with hairs. The eggs of the second or more broods, wherever such occur, are probably laid in similar situations; Koebele found them in California in August, 1889, on the stem, on the fruit near the stem, on the upper half and near the calyx of pears.

It seems that there has been considerable difference of opinion on the important question of *when* the eggs are laid; that is, at what stage in the development of the fruit are they laid. The records on this point vary from "just before the petals fall" to "nearly a month after the blossoms dropped." The common notion has been that the eggs were laid soon after the blossom fell, but apparently with no definite evidence to support it. When Koebele and Wier first found the eggs in California, the fruit was about an inch in diameter. In 1889, Gillette noted in Iowa that no worms hatched until nearly a month after the blossoms fell, and the apples were then an inch in diameter. Both in 1896 and 1897, we were unable to find any eggs on either early or late varieties of apples in orchards at Ithaca, N. Y., until the fruit had reached the size shown at *a*, *b*, *b* in figure 131; this was during the last week in May, and the blossoms had been off for a week or more and the calyx lobes had drawn together. Furthermore, moths did not begin to emerge in our cages in any numbers until a few days before we found eggs in the field, or not until after the blossoms had fallen even from later varieties. Mr. Card's careful observations in Nebraska in 1897 add corroborative evidence to the above. He found the first eggs on June 3d and the first worm on June 12th, while the petals had fallen from most varieties by May 10th.

Thus from the only definite evidence we have, one cannot escape the conclusion that, in the northern half of the United States at least, most of the eggs of the codling-moth are not laid until a week or more after the petals of the blossoms have fallen from most varieties of apples;* or usually during the latter part of May and the first half of June.

The date of the falling of the blossoms varies considerably in different years, depending upon the weather conditions which may cause spring to open early or late. As these same conditions affect the date of the emergence of the moths, in general the above statement regarding the egg-laying of the insect will hold good.

The observations of Goethe in Germany, show that most of the eggs are laid at night, when the moths are the most active.

The number of eggs and the egg-laying period.—Several guesses have been made of how many eggs one codling-moth may lay, and the estimates vary from two dozen to two or three hundred. There seems to be no definite observations upon this point, except what has been learned from an examination of the ovaries of the female. In 1873, LeBaron recorded that he found from forty to fifty tolerably developed eggs and a considerable number of undeveloped ova; that is, he found eggs in all stages of development in the ovaries. This shows that the egg-laying period must last for several days. Cooke records having a vial containing eighty-five eggs laid by one moth. Thus the number which one female lays may reach nearly a hundred.

As to how long after the emergence of the moths in the spring before egg-laying begins, accounts differ from forty-eight hours (Cooke) to six or eight days (Washburn).

Another stereotyped notion which has been handed down in the literature for more than a century is the statement that "the codling-moth has the wise instinct to lay but one egg on the same apple, and what is still more remarkable, she must have the instinct to avoid those apples which have been already appropriated to this purpose; since, otherwise, we should oftener find more than one worm in the same apple" (LeBaron). We have often seen two eggs on an apple no larger than the one shown at *a* in figure 131, and in one case we found five egg-shells, or perhaps sterile eggs (as we found no worms in the fruit) on such an apple; Koebele counted eleven eggs on a pear in California in August.

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* In the Rept. of the Gov. Entomologist of the Cape of Good Hope, South Africa, for 1896, which has just come to hand, Mr. Lounsbury records (p. 11) the following in regard to this phase of the codling-moth: "The insects were ovipositing at the time of my visit (in October). Not many eggs were found, but curiously enough, few of these at the blossom-end of the fruit, where they are said to be usually placed. At this time (October 20) some fruit was fully an inch in diameter and already contained the caterpillars, while unopened fruit buds were yet common on the trees, and many of the insects had not yet emerged from their cocoons. Such irregularity in the appearance of moth and in the setting of the blossoms make repeated applications of insecticides necessary."

Mortality among the eggs.—Our observations agree with those of Washburn, Goethe and Card that many apparently sterile eggs are laid by codling-moths.

Duration of the egg-stage.—Roesel stated in 1746 that the eggs hatched in eight days. Later observers record a variation of from four to ten days. The eggs under our observation hatched in about a week, and this is doubtless about the usual duration of this stage.

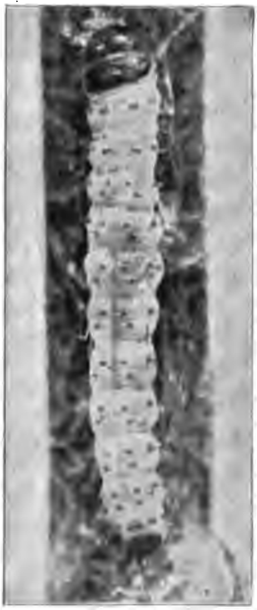
A day or two after the egg is laid, a narrow whitish or yellowish ring can be plainly seen through the shell. A day or so later this ring takes on a decided reddish tinge; it is visible in the picture of an egg at *e* in figure 131. Soon after this the black head of the developing caterpillar and the outline of its body can be plainly seen. At *h* in figure 131 is shown an egg with the little caterpillar almost ready to emerge.

The Young Apple-worm and its Habits.

How it gets out of the egg and its characteristics.—Roesel tells us in 1746, that the little caterpillar "comes out of that part of the egg where it lies on the fruit, so that the very small opening may not be observed, because it is yet covered by the egg-shell which still adheres." We find no other hint in the literature on this point until Washburn observed in 1892 that the young worms "broke or ate their way through the shell and entered the apple somewhere else than at the spot occupied by the egg." A caterpillar which we saw emerge, came out of the egg near the edge at one end. In the picture of an egg-shell at *es* and *es* in figure 131, one can see at the upper end a small black spot and extending from this to the right is an irregular whitish line which was the crack made by the worm when it pushed its way out.

A newly-hatched apple-worm measures scarcely a sixteenth of an inch in length, and is of a semi-transparent whitish color, with a shiny black head and blackish thoracic and anal shields. Usually the body is marked with many quite distinct blackish spots, regularly arranged and each bearing a short hair. In figure 132 is represented an apple-worm only a few days old, much enlarged, upon which these spots were very distinct.

The first meal of the little apple-worm.—We have seen some of the newly-hatched caterpillars eating their first meal. After emerging from the egg, those we saw wandered about upon the surface of the apple until they found some angular place like the opint where the calyx lobes join the skin of the fruit, or near the stem, or in an old curculio scar, or where a leaf or another apple touched the one upon which the worm hatched; often they simply crowded in between two of the calyx lobes and got their first meal within the little cavity at the blossom-end. In short, our observations agree with those of Koebele and Washburn that the young caterpillar enters the fruit somewhere else than at the point where the egg is laid.



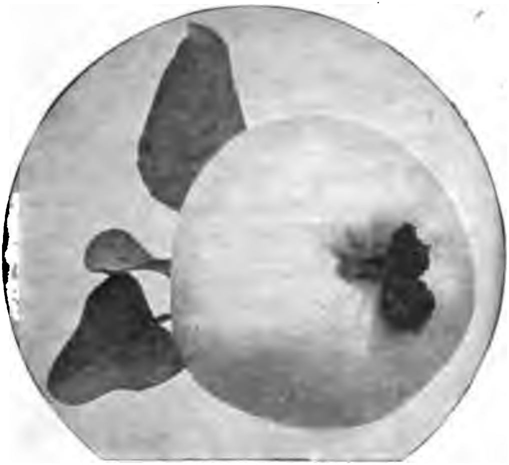
132.—*Young apple-worm only a few days old. Note the distinct spots on the body. Much enlarged.*

When a suitable place was found, the worm often tunneled its way through the skin and went directly toward the core. Where a leaf or another apple touched, the worm sometimes ate away the skin for a space about as large as a pin's head, before burrowing in; in this case the entrance-hole was closed with a net-work of silken threads in which bits of apple were intermingled. In one instance, a worm ate little holes through the skin near the stem in three or four places before it finally began its journey toward the core; other writers haved noted this same habit of the young worms in first entering a fruit. Thus the young caterpillar may get its first meal at almost any place on the apple, but usually this meal, or any subsequent meal for that matter, includes only a very small portion of the outer surface of the fruit, As has long been noted by writers, most of the young worms enter the fruit in the spring or early summer at the blossom-end. They either crawl between the calyx lobes or tunnel into the calyx-cavity at the point where the lobes join the surface of the fruit. Thus more often

the young apple-worm takes its first meals out of sight in the calyx-cavity and is protected by the tightly closed calyx lobes.

We have noted above that Mr. Card found most of the eggs of the codling-moth laid upon the leaves instead of on the fruit in Nebraska. In confinement, he found that the young worms sometimes fed for twenty-four hours on the leaves where they hatched, and ate out quite large pieces, usually eating away one skin of the leaf and the inner tissue, leaving the other skin intact. Whether they fed upon the leaves to any extent in the orchard was not determined.

Where it spends the first few days of its life.—Apparently the newly-hatched apple-worm spends but a few hours of its life on the skin of the fruit. Whenever it enters at any other point that at the calyx, it usually soon begins to tunnel toward the core. However, 75 per cent or more of the young worms enter the fruit at the blossom-end, and our observations indicate that they spend several days feeding around in the calyx cavity. When the worms hatch, the blossoms have been off for two weeks or more and the calyx lobes have drawn tightly together (compare figure 146 and *a* and *b* in figure 131) forming a covered cavity in the blossom-end of the apple; this does not happen in the case of the pear, as the central picture in figure 146 shows. This is a very important phase in the habits of the apple-worm, as we shall see when we come to discuss "remedies."



133.—*A wormy apple, showing the familiar mass of brown particles thrown out at the blossom-end by the young worm.*

All are familiar with the first indications that the apple-worm has begun work the masses of little brown particles which it thrusts out of the calyx are quite conspicuous, as shown in figure 133. These first few days of the apple-worm's life, which are usually spent in feeding in the blossom-end of the fruit, has proved to be the most vulnerable phase of the life of the insect. It is during this time that we kill it with a poison spray; just how this is done is discussed later on.

Habits and Growth of the Apple-worm Inside the Fruit.

The apple-worm's objective point soon after it enters the fruit seems to be the core. It usually reaches the core in about a week, and there begins its destructive work on the seeds, of which it seems to be especially fond, and on the surrounding flesh. It feeds in or near the core during the greater part of the remainder of its life in the fruit. As it feeds, it increases in size and has to shed its skin from time to time to accommodate itself to this growth; it is said that the caterpillar sheds its skin four times while feeding in the fruit. As the worm increases in size, its head and thoracic and anal shields change in color from black to brown, and the small blackish piliferous spots, so distinct in the young worms, as shown in figure 132, usually become quite indistinct; we have, however, seen nearly full-grown apple-worms on which these spots were still very distinct. The body of the worm also acquired a distinct pinkish or flesh color, sometimes even when the worms are only half-grown.

While at work in the blossom end or in tunneling to the core from any point on the fruit, the young worms apparently try to keep their home clean by throwing their excrement out at the entrance hole. Once fairly at work in the core, however, little or no trouble is taken to remove the grains of excrement; they are often found in the worm-cavity fastened together by silken threads.*

Preparations for leaving the fruit.—Several days before the apple-worm gets full-grown, it proceeds to eat a passage way, usually by the shortest route, toward the exterior. This exit-tunnel often follows the entrance burrow, and thus often opens at the blossom end, but usually the external opening or, familiar "worm-hole," occurs in the side of the fruit. When the worm reaches the surface with its exit-tunnel, it uses the opening as a door out of which it throws its excrement; it apparently keeps the hole closed with a net work of silken threads in which are mingled particles of apple bitten off by the worm and with grains of excrement. An exit hole thus stopped up is shown, enlarged, at *a* in figure 134. This "worm-hole" often remains in this condition for several days, the caterpillar evidently feeding inside and making further preparations to leave the fruit forever.

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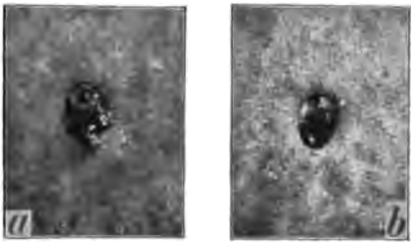
* Reaumur thought this was purposely done by the worm to prevent the pellets from being thrown about in the cavity by the motions of the fruit. This may be true, or it may be more probable that, like many other caterpillars, this apple-worm spins a thread wherever it goes around in its home, and the pellets simply get entangled in these threads.

The codling-moth usually spends from 20 to 30 days of its life as a caterpillar feeding inside the fruit.



134.—*The "worm-hole" or exit-hole of the apple-worm; enlarged.* a, *before the worm has left the fruit and* b, *after it has emerged and pushed away the plug.*

Are two or more fruits ever attacked by the same worm?—Roesel believed that the worms often went from one apple to another, even though the apple fell to the ground and the worm had to climb the tree again. Later observers have only seen indications of where a worm has left one fruit and entered another touching it while the fruits were still on the tree. There is no authentic evidence to show that more than two apples are ever entered by the same worm. Usually the apple-worm gets its growth in the same fruit where it got its first meal.

The number of worms in a single fruit.—Usually but one apple-worm occurs in a fruit, but several instances are recorded where two, three, or even four worms have been found in one fruit. Out of 201 apples examined by Atkins, in Maine, in 1882, 9 had been penetrated by three worms each, and 47 by two worms each; in no case did a worm gnaw through into the burrow of another. When two or more worms are found in the same fruit, they are usually quite different in size, and may belong to different broods.

Effect of their work on the fruit.—Usually fruit in which the apple-worm is at work show signs of a premature ripening. This is especially true of early varieties, and "windfalls" are often the final result. In the case of late varieties, however, the infested fruit often remains on the tree and ripens naturally with the others, the worms thus having but little effect on the fruit, except to render it unattractive to buyers and eaters. Usually "wormy" fruit is practically worthless for almost any purpose, but much of it is often fed to stock or to us in the form of sweet cider.

How and When the Worms Leave the Fruit.

When the caterpillar is ready to leave the fruit it pushes away the plug of pellets, described above and shown at *a* in figure 134, and crawls out, leaving a round, blackish-looking "worm-hole" as shown at *b* in the same figure. When this exit-hole is found, one can easily tell whether a fruit still contains the worm or not by the presence or absence of the plug of pellets. It is said that the worms leave the fruit mostly at night.

If the fruit has already fallen to the ground, the caterpillar proceeds to crawl to some secure and suitable place in which to begin its preparations for becoming a moth. Those worms which leave the fruit on the tree, were seen by LeBaron in the orchard by lamp-light to either let themselves down to the ground by a silken thread, which they spun as they went, and then crawl back to the trunk; or they crawled from the apple onto the branch and thence down to the trunk. Cook, from some experments made in 1875, thought that the worms seldom, if ever, dropped from the tree to the ground; and that at least one half of them did not descend to the ground at all. Trimble records collecting a number of worms and putting them on the ground in the vicinity of an apple-tree. They crept about at random for a little while, but if not too far off, most of them were soon seen going in the direction of the tree.

The date when the worms which enter the fruit in the spring get full-grown and leave, can not be stated definitely. For the irregularity in the appearance of the moths at that time is so great that oftentimes some of the earliest worms will be ready to leave when others hatched from later eggs will be just entering the fruit. In the latitude of St. Louis, Riley records finding full-grown worms as early as the 5th to the 10th of June. Usually, however, the early summer brood of worms in the latitude of New York do not mature until July and later. From the first of July until winter sets in, one can usually find at any time worms of all sizes in the fruit; and large numbers of them do not leave the fruit until it has been barreled or stored for winter.

The Cocoon.

Where it is made.—After leaving the fruit, the apple-worm next devotes its energies to finding a suitable place for its cocoon, in which to undergo its further transformations. Many of them find their way to the trunk, larger branches, or into the crotch of the tree, where they crawl into any crevice they can find under the rough, loose bark. Other worms find suitable quarters on near-by fences or trees, in piles of rubbish, under boards or chips, in stumps, in fact, almost anywhere, except in the ground or among the grasses or weeds.* In November, 1875, Beal made a very careful examination of several square feet of soil and grass under different trees which had borne or had had wormy apples sorted under them; no trace of the insect was found.

If the worms are carried into the store-rooms or barreled with the fruit when it is picked, upon leaving the apples they spin their cocoons in the crevices and angles of the barrels, or anywhere in the store-room, especially in any rags, papers, or clothes that may be lying about.

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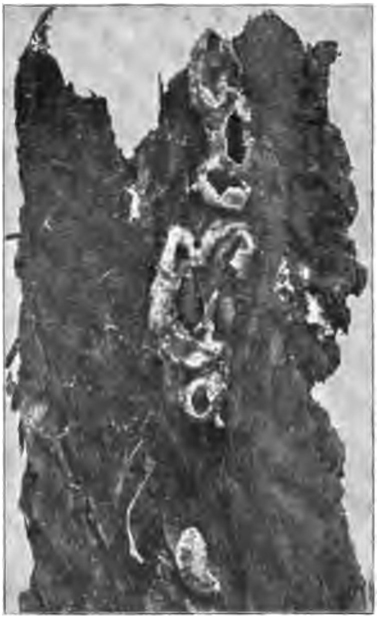
*Mr. Crawford records an instance in Australia where the worms took refuge in the pith of old raspberry canes growing under apple trees; 20 worms were found in one of these canes. In 1896, several raspberry canes, which had been badly infested with the cane-borer, were sent us from Ohio. In the pith, we found several apple-worms snugly tucked away in their cocoons. In this case, the worms had evidently found an easy entrance to the canes through the large hole made by the borer when it emerged as a beetle. While breeding the insect here in the insectary, we have had the worms burrow into pieces of cork and work their way into books to spin their cocoons. Cooke says the cocoons are often found in California from one to six inches below the ground on the base and roots of the smooth-barked trees.

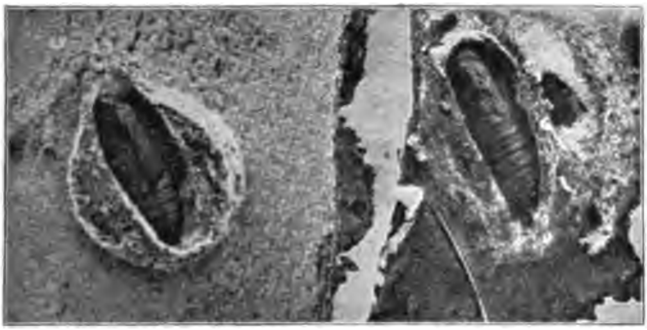
How it is made.—Having found a suitable place, the appleworm first usually hollows out with its jaws a little oval cavity, and then begins its cocoon. The cocoon is rather thin but quite tough and is made largely of silk in which are mixed bits of the substance on which it is being made. It is lined with a thin layer of white silk, and on the outside it is usually covered, and often thickened at some point, with more loosely bound together particles of the surrounding substance; this renders the cocoon quite inconspicuous. Several cocoons are shown, natural size, in figure 135 just as they appeared on the piece of bark when it was removed from the tree. Figure 136 shows some cocoons enlarged, and it well illustrates their method of construction. In shape, the cocoons are adapted to the shape of the place in which they are built. Anyone can soon find these cocoons on old rough-barked apple-trees after a little search at almost any time from August 1st until spring opens. Cooke states that a worm completes its cocoon in twenty-four hours. It is said that the cocoons made by the worms late in the season, and in which they expect to pass the winter, are tougher, thicker, and darker colored than those made earlier, from which the moths soon issue.



135.—*Cocoons of the codling-moth as they were found attached to a piece of loose bark, natural size.*

How Long and in what Condition the Insect Lives in its Cocoon.

Usually when the cocoon is made during or after August, the insect may be found therein as a caterpillar until the next spring. If the cocoon is made before August 1st, its maker, the caterpillar, may change within three days to a very different looking object known as the *pupa*. Cocoons containing these pupæ are shown, natural size, in figure 135, and enlarged in figure 136. The insect usually spends but two or three weeks, sometimes less, in the pupa state, whether the change to a pupa takes place in July or not until the next spring. Thus the insect may spend less than three weeks of its life as a pupa in the cocoon, or it may occupy it as a caterpillart for ten months, and then as a pupa for two or three weeks longer. The reason for this seemingly great variation in the life-history of the codling-moth will appear in the discussion of the next and very important phase of the subject.



136.—*Pupae of the codling-moth in cocoons, enlarged.*

The Number of Broods of the Insect.

For more than a century the statements which have been made regarding the number of broods of the codling-moth during the course of a year, have differed widely. Some writers record only one brood, others two, and some as many as three or more in a year. This variation has been the subject of considerable discussion in Germany, and more recently in the United States.

Beginning with Goedart's first account in 1635, the European records indicate but one brood north of latitude 50 degrees, that is in England, Holland, Germany (except possibly the southwestern portion), and the more northern countries. The evidence from Reaumur, Pissot, and Schmidtberger indicate two broods in France and Austria or south of latitude 50 degrees; recent evidence from Italy indicates three broods there.

In America the evidence thus far submitted, shows a similar, and in some instances a more striking variation in the number of broods of the insect. The observations of Atkins, Harvey, and Munson in Maine, indicate one regular or full brood and a partial, in some years possibly nearly a full, second brood in that state. This statement will doubtless also apply to most of the New England States, and so far as our observations indicate, it is also true of New York state.

In 1871, Mr. Chapin, of East Bloomfield, N. Y., found that by caging some of the insects in July that a second brood of the moths appeared in August (*Country Gentleman*, Jan. 25th, 1871.) We have bred moths in August here at Ithaca from cocoons spun in July, and our observations indicate that in New York state the number of worms of the first brood which develop into moths the same season depends largely upon the weather conditions which affect the earliness or lateness of the opening of spring. In 1896, for instance, spring opened earlier than usual in New York and everything was very favorable for the development of insect life for several weeks, with the result that there was evidently nearly if not quite a full second brood of the codling-moth, for a much larger percentage of the apples than usual were injured late in the season. We believe that there is always a partial second brood of the insect in New York, and in some years probably a full second brood in many parts of the state.

There is conclusive evidence of two full broods of the insect in Illinois, Iowa, Missouri, Kansas, Nebraska and Colorado, with indications of a partial third brood in southern Illinois and in Nebraska and Colorado. In the higher altitudes of California there are apparently but two broods (Bull. 22, U. S. Div. of Ent., p. 89), while three broods appear in other parts of the state. Observations in Oregon and New Mexico indicate three broods there also.

The evidence submitted from New Jersey indicates some peculiar variations in the life of the insect in that state. In 1865 Trimble recorded that he found pupæ under some of his bands at Newark, N. J., on August 10th, and on August 20th and 23d he found that "about one in five of the worms had transformed to moths;" thus demonstrating at least a partial second brood in that part of the state. In 1894, Smith recorded some experiments extending over three years, from which he recently concludes that "near New Brunswick there is positively a single annual brood only." But he admits that "south of Burlington county there is at least a partial second brood." In the same paragraph he also states that the moths emerge earlier at New Brunswick than Card records them in Nebraska, where there are at least two broods of the insect. It seems strange that there should be such a difference in the life of this insect within a distance of less than thirty miles in the same state. But there seems to be something peculiar about the conditions near New Brunswick, N J., for Smith finds that other insects, notably the elm leaf-beetle, lead a different life there than they do only a comparatively short distance either to the north or south.

In 1895 Fletcher reported that "careful observations made during the last ten years convince me that in this part of Canada (Ottawa) there is only one regular brood of this insect in the year. This is, I believe, the case as far west as Toronto. In the fruit-growing districts of West Ontario there are two broods, the second brood being invariably the most destructive."

From the above evidence we conclude that there is one well-defined brood and usually a more or less complete second brood of the codling-moth yearly in the New England States, New York, most of New Jersey, and part of Canada. Two well-defined annual broods occur in Michigan, Illinois, Iowa, Missouri, Kansas, Nebraska, Western Ontario, and Colorado, with sometimes a partial third brood in some localities and seasons. In California, Oregon, New Mexico, and in the South there seems to be three broods annually. We should have more definite observations on this point in many states. It is not possible to define these different regions by parallels of latitude, for the variation in the number of broods depends upon differences in climate, temperature, and altitude.*

Whenever the first brood of worms transforms into moths the same season, this usually occurs late in July and during August, and the second brood of worms work from August on, many of

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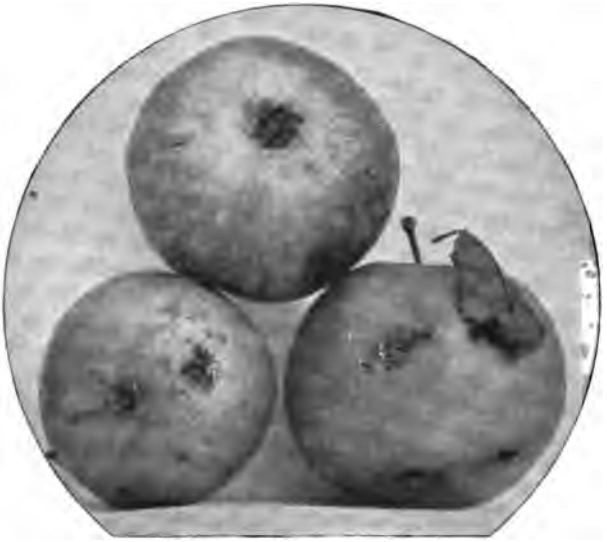
*Mr. Marlatt suggests (Proc. Ent. Soc. of Wash., III., p. 228) that "Dr. Merriam's map showing the distribution of the total quantity of heat during the season of growth and reproductive activity, presents an interesting agreement in its zones with the available records in regard to the number of broods of this insect. * * * At least, a good basis is furnished for future observations." He thinks that the data thus far submitted indicates one annual brood in Dr. Merriam's transitional zone, two annual broods may be expected in the upper austral life-zone, and three annual broods in the lower austral zone.

them even completing their growth after the fruit is stored. In those parts of Europe where the insect is single-brooded, the moths do not appear from the winter cocoons until the middle of June and in July. The second brood is usually more destructive than the first, as it is more numerous and works in the later and more valuable varieties of fruit. In some years the partial second brood which works in New York state spoils many more apples than the first brood.



137.—*Wormy-spots made by the second brood of apple-worms, half natural size.*

This question of the number of broods of this pest is of great practical importance in connection with the methods of combating it. We have learned how to quite successfully control it where there is one and a partial second brood, or even two broods annually, but where there are more than two broods we are not so successful.

How the Second Brood Works.

Doubtless the eggs of the second brood, like those of the first, are laid anywhere it happens on the fruit or possibly on the leaves, but not so many of the young worms enter the fruit at the blossom-end, many of them entering at other points. Instead of making their way to the core soon after entering, many of the worms of the second brood seem to feed for some little time in the flesh just beneath the skin near the point where they entered, forming there a shallow mine. This results in a large wormy spot which greatly disfigures the fruit, as shown on the two lower apples in figure 137; often a leaf may be fastened down to the fruit over the spot, as shown on one of the apples. In 1896 there was much complaint from New York apple-growers on account of so much of their fruit having these wormy spots on them late in the season; most growers did not realize that it was the work of their old enemy, the codling-moth. Perhaps the more common method of work of this second brood, however, in many localities is shown on the upper apple in figure 137. That is, the worm enters the blossom-end, but instead of soon making its way to the core, it extends its feeding grounds out into the fruit around the calyx, forming a shallow mine just under the skin. Sometimes the flesh is thus mined out for a distance of half an inch from the calyx, the worms often attaining their full growth there. Harvey records that in Maine, in 1888, three-fourths of the apples from some localities showed this work of the second brood of worms around the calyx. Whether the second brood often works in this peculiar manner in other parts of the country, especially where there is a third brood, we cannot say. It is probable that many of the worms which are hatched late the season, of whatever brood, work in this manner.

How the Insect Passes the Winter.

Almost invariably the codling-moth winters as a caterpillar in its cocoon. Differences in latitude, climate, or altitude seem to cause no variation from this rule.* Often some of the worms go into winter quarters in August. As worms of all sizes may be found in the fruit late in the fall, doubtless many of the young ones perish, unless they are lucky enough to be carried into the store-room where they may continue feeding and finish their growth.

One can readily find these hibernating worms in the winter or early spring, snugly curled up in their cocoons, by carefully examining the loose bark on almost any old apple-tree which bore much fruit the previous season. It is interesting to watch the caterpillars when their cocoon has been torn open, even in the winter. They soon bestir themselves and proceed to repair the damage at once. If removed from the cocoon they will spin another, and we have had a worm make two or three new and complete cocoons after being removed very early in the spring from the one in which it hibernated.

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*Mr. Howard records an apparent exception to this rule. Specimens of the insect were received at the Dept. of Agr. from Kansas, on November 15th, were in the pupa state when sent three days before. They were kept in a warm room and the moths issued in January.

When the Moths Appear in the Spring.

Those hibernating worms which escape the birds during the winter, change to brown pupæ, shown in figure 136, in the spring, and in from two to three weeks the moths emerge. The date of the emergence of the moths depends much upon the place where the worms hibernated, and upon the weather conditions prevailing in the spring. Oftentimes the cocoons are spun in temporary storerooms in the fall, where the subsequent temperature is so warm as to cause the insect to transform considerably sooner than it naturally would on the trunk of a tree; or if the wormy apples are placed in a cool cellar, the transformation of the worm may be unnaturally prolonged. The recorded appearances of the moths vary from March and the first half of April in California, through May and the early part of June for most localities in the northern half of the United States, and some moths have not emerged from cellars or storerooms until July 13th or later.

During the past two years we have made many visits to orchards early in the spring and have collected and examined hundreds of cocoons. These were placed in cages and the worms allowed to transform into moths, the date of emergence of the latter being noted. In 1896, we began collecting April 8th and found only caterpillars in the cocoons until April 28th, when one or two pupæ were seen. In 1897, the first pupa was found April 27th, and by the 7th of May only about one-fourth had pupated in the cocoons on the trees. The following table gives the dates of the emergence of the moths (with the number for each day) from cocoons collected in April, 1896 and 1897.

1896.				1897.	
Date.	Number of Moths.	Date.	Number of Moths.	Date.	Number of Moths.
May 3	1	June 1	8	May 24	4
“ 4	1	“ 2	6	“ 26	4
“ 5	2	“ 3	7	“ 28	5
“ 7	4	“ 4	6	“ 29	3
“ 10	4	“ 5	9	“ 30	8
“ 11	5	“ 6	4	“ 31	6
“ 17	5	“ 7	5	June 2	6
“ 25	5	“ 8	6	“ 3	9
“ 26	4	“ 9	9	“ 4	7
“ 28	5	“ 10	1	“ 6	6
“ 29	4	“ 11	1	“ 7	6
“ 30	2	“ 12	5		
“ 31	3	“ 13	4		
		“ 18	1		
		“ 21	2		
		“ 22	2		

The above table shows that the moths may emerge over an unusually long period in the spring in central New York; that is, from May 3d until June 22d, or over a month and a half. Apparently a majority of them emerged in 1896 and 1897 during the last week in May and the first week in June. We found the first eggs in the orchard on May 28th in 1896, and recently-laid eggs, evidently of the first brood, were seen as late as June 27.

Compared with the blossoming period of apples.—The date of the opening of apple-blossoms varies considerably in the same localities in different years, depending upon the earliness or lateness of the opening of spring.

At Ithaca in 1896, the petals had fallen from most varieties by May 10th, and by May 28th the fruit was as large as shown at *a* and *b* in figure 131. In 1897, however, early varieties of apples were not in full bloom until May 11th, and the petals had not fallen from the later varieties until May 20th. In the same locality in 1892, Lodeman found that the petals were not off until June 6th; in 1893, he found that the first blossoms opened on May 19th, and a few blossoms remained on June 8th. In 1892 the blossoms were off by May 20th in Pennsylvania. It is recorded that at Benzonia, Mich., the season was so late in 1888, that there were no apple blossoms for Decoration Day, May 30th; while the same year in California, the apples were in bloom March 17th. In 1889, the petals had fallen in Iowa by May 15th, and in 1891, Munson records that the last blossoms were falling in Maine on June 11th. In New Hampshire, the blossoms had fallen by June 9th in 1894. In 1897, Card reports that the season was later than usual in

Nebraska and the petals fell about May 8th. In 1888, a calendar was kept of the date of blooming of different varieties of apples in Kansas (First Rept. Kan. Expt. Station); the calendar shows only a few days, less than a week's, difference in time of blooming of the earliest and latest varieties, most of them being in full bloom about April 21st.

The above evidence in regard to the blossoming time of apples as compared with the dates of the emergence of the codling-moths, indicates that the moths may begin to emerge about the time the apple-trees are in bloom. But our breeding experiments and what little definite evidence there is on this point, indicate that the majority of the moths do not emerge until several days after the petals have fallen. Then allowing a few days for the preparation for oviposition, we should not expect, and, in fact, do not find eggs until a week or more after the petals drop. Another week must elapse before the eggs hatch, so that theoretically, we should find but few worms until after the blossoms have been off for two weeks or more on most varieties; and this agrees with our observations and with the definite evidence recorded by Atkins, Gillette, Washburn and Card. There is no definite evidence that eggs have been seen on apples on the tree until the fruit has reached nearly the size shown at *a* and *b* in figure 131, or until it is from one-half to three-fourths of an inch in diameter.

We have gone into some detail to bring out the above facts, not only because they correct some old stereotyped notions, but because they have a very important bearing on the question as to when it is necessary to apply the spray to reach the worms the most successfully. As will be brought out more fully, with illustrations, in our discussion of the time to spray, it is necessary for fruit growers to watch the blossoming of their trees and especially the development of the young fruit, for therein lies an easy and sure method of determining just when the spray can be applied to do the most good.

Habits of the Moth.

It has long been known that the adult insect was nocturnal in its habits, usually remaining hidden during the day. The fact that the moth closely mimics the bark in its coloring, and its habits of moving about only at night, account for the fact that but few fruit-growers have ever seen it. Kœbele gives the following account of their habits in California: "On a hot and sunny day, while walking through an old apple orchard at 10 A. M., moths started up either from the trunk or lower leaves of nearly every tree and settled down again, generally higher up and on the upper side of the leaves exposed to the sun. From May 25th until the end of June there could be seen at dusk from 25 to 50 on each tree. The place is situated on the east side of the hills. About half an hour after the sun disappeared behind the mountains, and while it was yet visible for nearly that length of time on the opposite hill, the moths began to appear, flying with quick movements around the trees, chiefly near the tops, and settling down again upon the leaves or fruit from time to time. This was kept up until towards dark when they became less numerous. During this time both sexes may be readily collected with a long butterfly-net. I have taken many near the ground on the lower leaves and often distant from fruit trees. By their peculiar flight they are easily distinguished from any other species of moth." Gœthe found in his experiments in Germany that the moths were the most active about 9 P. M. Most of the eggs are thus doubtless laid in the evening.

Unlike many other moths, the codling-moth is not attracted to lights. This has been demonstrated several times by careful experiments with trap-lanterns in orchards.

The moth has a slender, pointed tongue with which it sometimes sips or sucks up sweet substances. LeBaron saw the moths feed freely upon lumps of moist sugar and slices of sweet apple which he placed in their cage. McMillan records that they willingly feed upon sweetened water, and that he has "seen those of the second brood feeding upon the yellow flowers of an autumnal composite (*Grindelia squarrosa*) in the dusk of evening" in Nebraska. The weight of evidence from careful experiments indicate that the moths are not easily attracted to alluring baits of any kind.*

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*A Connecticut correspondent states in the *Rural New-Yorker* for Jan. 9th, 1897, that "happening to pass a sweet-bough apple-tree one evening in August, where a number of apples, half eaten by the chickens, were lying scattered about, I noticed a kitten busily trying to catch some

How long a codling-moth lives is not definitely known. In confinement, most observers record that they all die in about a week. Washburn concluded from his observations that the life of the moths was from ten to fifteen days. One moth lived for seventeen days in one of our cages.

Brief Résumé of the Life-history.

The codling-moth appears in the spring about the time the blossoms are falling from apple trees, and after a few days glues its tiny scale-like eggs (see figure 131) onto the skin of the young fruit or even the adjacent leaves, where they hatch in about a week. The little apple-worm usually finds its way into the blossom-end where it takes its first meal and where it remains feeding for several days, finally eating its way to the core. In about three weeks it gets nearly full-grown and makes an exit-tunnel to the surface, closing the outside opening of the tunnel for a few days while it feeds inside. Emerging from the fruit, it usually makes its way to the trunk of the tree where it soon spins a cocoon (figure 135) under the loose bark. Usually the first worms to thus spin up in June or July, soon transform to pupæ (figure 136), from which the adult insect emerges in about two weeks, and eggs are soon laid from which a second brood of the worms hatch. In most of the more northern portions of the United States, only a part of the worms of the first brood pupate or transform to moths the same season, but in the central, western and southern portions there is a complete second brood, and in some portions even a third brood of the worms annually. In the fall all the worms spin cocoons wherever they may be, either in the orchard or in store-rooms, and remain curled up in them as caterpillars until spring opens, when they transform, through the pupa, to the moth, thus completing their yearly life-cycle.

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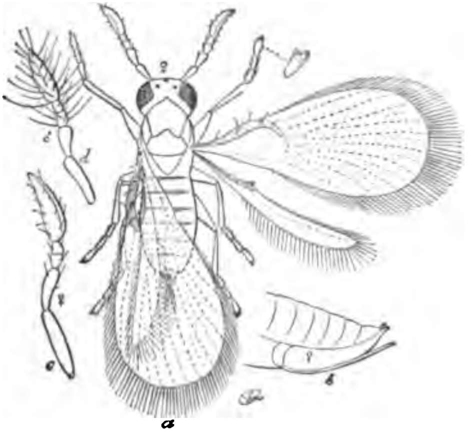
small object. On investigation, I discovered that the half-eaten apples were covered with codling-moths. There were thousands of them, apparently feeding on the fruit. They were very active when disturbed. I procured a lot of old newspapers, and for half an hour or more I kept several fires burning brightly, while the kitten and I stirred them up. I don't think I succeeded in burning as many as the kitten caught. They carefully avoided the fires."

THE NATURAL ENEMIES OF THE CODLING-MOTH.

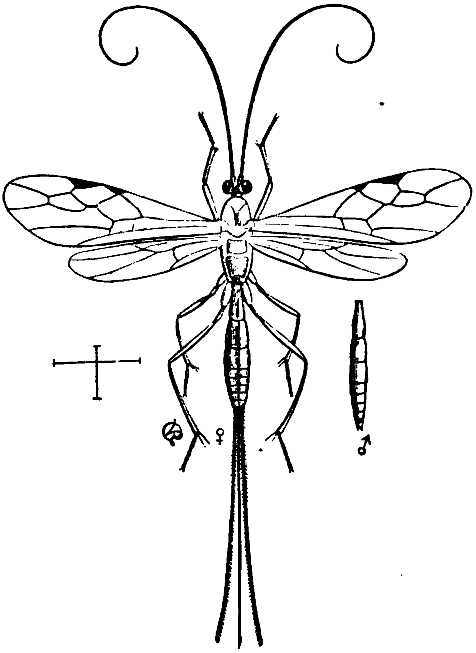
At no period of its existence does the codling-moth seem to be secure from the attacks of its enemies, even the tiny eggs and the moth do not escape their relentless jaws.

Koebele records that in California a "most efficient destroyer of the insect, is a small bat which is always in search of the moth, appearing somewhat later than the latter, but keeping up its chase until dark, when apparently the moths cease their flight and the bats go off in search of other food. Every night during June as many as six of these bats were to be seen flying around an isolated apple-tree upon which there were a large number of the moths, not only taking the codling-moth on the wing, but very often darting at a leaf to get the resting moth."



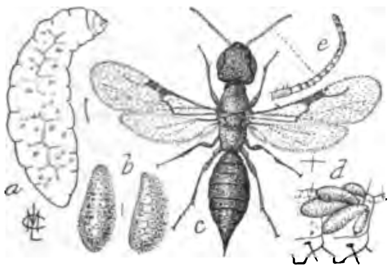
138.—*Trichogramma pretiosa.* Egg-parasite of the codling-moth, greatly enlarged. From (Riley, 4th Rept. Ent. Com., U. S. Dept. of Agr.)

It would seem that the codling-moth's egg, not quite so large as a common pin's head, would escape the eye of the enemy, but many of them do not. In June, 1896, we were surprised to find that quite a number of the eggs we saw had a peculiar black appearance. These were placed in cages, and a few days later the mystery was explained. For instead of little apple-worms hatching from them, there appeared fully developed adult insects, the surprising number of four coming from a single tiny egg in some cases. It is wonderful to think of four perfect animals having been born in, and having obtained sufficient sustenance to develop into perfect insects from the contents of such a tiny thing as the egg of a codling-moth. In figure 138 is shown a greatly enlarged picture of this pretty little parasite, which is of course an exceeding small creature, yet it is easily visible to the naked eye. Dr. L. O. Howard determines these little parasites as probably the same insect, *Trichogramma pretiosa*, which infests the eggs of the cotton worm to a large extent in the South. In 1889, Koebele found many parasitized eggs of the codling-moth in California; the parasite he reared is either the same as, or first cousin to, the one working in the eggs in New York.

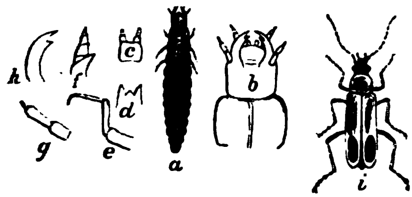


139.—The delicate long-sting parasite (*Macrocentrus delicatus*. (From Riley.)

Even after the apple-worms get out of sight in the fruit, they are not safe from their enemies. In California a wasp (*Sphecius nevadensis*) is reported to frequent pear trees and is described as pulling the worms out of the fruit with its "fore foot." In 1890, Mr. Webster reported (Insect Life, III., 348) that two observers in Indiana had seen downy woodpeckers deftly extracting the worms from the blossom-ends of young apples, without injuring the fruit. In 1873, Dr. Riley found that an Ichneumon fly, which he called the "delicate long-sting," "probably pierced the unfortunate apple-worm while yet in the fruit, as it always succumbs soon after forming its cocoon, and before changing to a pupa." Riley's picture of this graceful, pale honey-yellow parasite is given in figure 139; the lines at the left show its natural size. While examining wild haws in 1890 for apple-worms, we were surprised to find in a few fruits nearly full-grown worms whose life was being sucked out by small maggot-like creatures which had attached themselves to the body of their host, one to each apple-worm. We did not succeed in rearing the adult insect from this external parasitic grub. It may have been the same parasite which Popenoe found in Kansas in 1889, but he does not state whether the apple-worm was attacked while in the fruit or not. A picture of this Kansas parasite, which Dr. Howard writes us is probably a species of *Goniozus*, is shown greatly enlarged in figure 140. In 1872, Mr. Foster, of Babylon, N. Y., reported (*Gardner's Monthly*) the discovery of a very curious and strange case of parasitism. He had found a species of the well-known hair-snakes imbedded in one of the codling-moth caterpillars in the center of a large pear. Since then several observers have found these hair-snakes either in apple-worms or coiled up in the core of wormy apples. Hair-snakes are often found in ground-inhabiting insects like grasshoppers, but how they ever get into apple-worms inside the fruits on the tree is yet a mystery. A German writer suggests that a heavy dew may moisten the trunks of trees sufficiently to enable the hair-worms to ascend them. The apple-worm is also infested by a hair-snake in Europe.



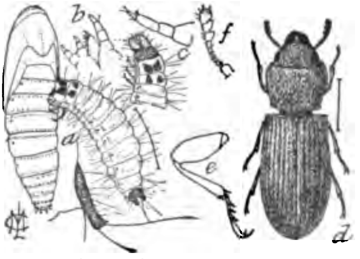
140.—*Goniozus sp.* externally parasitic on apple-worms. (From Popenoe.)



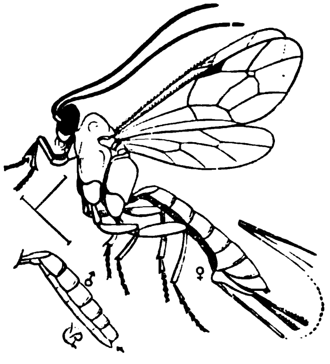
141.—The Pennsylvania Soldier-beetle (*Chauliognathus pennsylvanicus.*) (From Riley.)

After the apple-worm leaves the fruit, it has to run the gauntlet of many other enemies. The larva (*a* in figure 141) of the Pennsylvania soldier-beetle (*Chauliognathus pennsylvanicus*) often devours the apple-worm while it is getting ready to spin up, and possibly sometimes before it leaves the fruit. The adult form—the beetle—(*i* in figure 141) of this predaceous enemy is a very common yellowish beetle which feeds only on the pollen of flowers. It is probable that the larva of the margined soldier beetle (*C.*

marginata) also even enters the fruit to feed upon the apple-worm. The larva of the two-lined soldier-beetle (*Telephorus bilineatus*) is also reported as preying upon apple-worms. Still another predaceous beetle larva, which has been found feeding on the apple-worm, and the pupæ also, in many parts of the United States, is shown at work at *a* in figure 142. We have seen many of these larvæ at work in our search for apple-worms on the trunks of trees in early spring. With the exception of the birds, it seems to be the most efficient enemy of the codling-moth in New York. Its first cousin, *Trogosita laticollis*, also has the same habit. In California, the larva of a Raphidian (a Neuropterous insect occurring only in the far West) is a most effective enemy of the apple-worm. An attempt has been made to introduce this insect into Australia to help in keeping this pest in check there. A Tachinid fly (*Hypostena variabilis*) is recorded as having the apple-worm for its host (Bull. 7, Tech. Ser. U. S. Div. of Entomology, p. 17). Besides these predaceous ene mies, thereis a parasitic Ichneumon-fly which attacks the apple-worm after it leaves the fruit. This black parasitic fly is shown much enlarged in figure 143. It is known as the ring-legged Pimpla (*Pimpla annulipes*). The grubs of this fly live within the body of the apple-worm or the pupa, and the adult fly escapes by eating its way through the pupa skin and cocoon of its host.



142.—*Trogosita corticalis.* Note the predaceous larva at work on a codling-moth pupa. (From Popenoe.)



143. The ring-legged Pimpla parasite (*Pimpla annulipes.* (From Riley, An. Rept. Sec) of Agr. for 1897.)

In Europe, three parasites are recorded as attacking the codling-moth ; they are *Campoplex pomorum*, *Pachymerus vulnerator*, *and Phygadeuon brevis*.

By far the most efficient aids to man in controlling the codling-moth are the birds. Nearly all writers since Roesel's time, 1746, have referred to the effective work done by the birds. Anyone who tries to collect the apple-worm on the trunks of the trees in early spring, will be surprised to find how many empty cocoons there will be. Usually, however, a tell-tale hole through the bark into the cocoon, explains the absence of its occupant. Our observations lead us to fully agree with Riley and Walsh that "almost all the cocoons of the moth that have been constructed in the autumn on the trunks and limbs of apple trees, are gutted of their living tenants by hungry birds, long before the spring opens." In our experience, it was almost impossible to find anything but empty cocoons on any part of the tree in the spring, except on the trunk at the surface of the ground and for a distance of from six inches to a foot above. One finds such an astonishingly large number of empty cocoons, that it would seem as though the birds must get the larger percentage of the worms which go into hibernation in the fall. Among the birds which thus include the apple-worm in their menu are the downy woodpecker, nuthatch, black-capped titmouse, bluebird, crow blackbird, king-bird, swallows, sparrows, wrens, chick-a-dee, and jays. It is probable that most of the birds which winter in any locality, include the apple-worm in their dietary.

Recent reports have appeared in horticultural papers that the fruit-growers of Oregon and Washington were trying to arrange for the importation of a German bird which is said to be a natural enemy of the codling-moth. Our advice to a correspondent, who wrote us from Washington in regard to the scheme, was "do not try it." There are too many risks to run. In the first place, it is very doubtful if there is any German bird which gets as many apple-worms to eat in its native home as do some of our own native birds in our orchards. As the *Rural New Yorker* puts it: "This foreigner should furnish a certificate of good moral character before being allowed to land." The English sparrow was introduced into the United States to destroy canker-worms, and to-day it is an unmitigated pest, while the canker-worms were never more numerous and destructive than now. Dr. L. O. Howard, in a recent address (Proc. Am. As. Ad. Sci. for 1897) has well said: "We have thus had sufficient experience with intentional importations to enable us to conclude that, while they may often be beneficial in a high degree, they form a very dangerous class of experiments and should never be undertaken without the fullest understanding of the life-history and habits of the species. Even then there may be danger as, with a new environment, habits frequently change in a marked degree."

And yet, in spite of the above array of enemies, enough codling-moths succeed in running the gauntlet every year to allow it to take rank as the most destructive apple pest in nearly all parts of the world.

HOW TO FIGHT THE CODLING-MOTH.

The codling-moth seems to have ravaged orchards for twenty centuries before anyone recorded any suggestions by which it might be checked.* During the past seventy-five years, however, so many schemes have been devised that it would require volumes to contain all that has been said pro and con concerning them. Believing that oftentimes it is just as valuable to a fruit-grower to know *what not to do* as it is *what to do*, and that one method may be more applicable or practicable under certain conditions then another method, we have thought it advisable to briefly discuss all of the so-called "remedies" that we have seen suggested.

In devising any method for combating an insect foe, the first thing that should be considered is, in what stage or when is it the most vulnerable to attack? Recommendations for fighting the codling-moth include schemes for reaching it in all stages and under all sorts of conditions. Most writers have considered that the insect is not so easily gotten at in either of the shorter stages of its life, that is, in the moth, egg, or pupal stages, there-

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*Of interest historically, is the fact, that so far as we can discover, the first one to even hint at any remedial measure was an American, a Mr. Thatcher. In the second edition of his *American Orchardist*, he shrewdly reasons that as the worms are said to spend the winter on the trunks of the trees, it would be well to scrape off all loose bark and apply Forsyth's wash (consisting of soap-suds, lime, and cow-dung) ; this would certainly help in reducing the numbers of the pest.

fore most of the remedial suggestions are directed toward the destruction of it in the caterpillar stage, in which it spends the greater part of its life.

What can be done Against the Moths?

"Rusticus" said in 1833, that one could drive away the moths in June by making a smoking fire of weeds under valuable trees. This is possible, but hardly probable, and not often practicable. In 1839, Freyer suggested that the best way is to hunt out the moths on the trunk and leaves and kill them. He must have been joking, for we have never yet been able to get sight of the moth on a tree. Ratzeburg condemned the method the next year.

The insect-catching properties of the flowers of the different species of *Physianthus* have long been known, and there has been considerable discussion over the claim made by some that many codling-moths were caught in these flowers. It was proposed to train these vines up the trunks of apple-trees, surmising that the flowers by capturing the moths, would thus protect the crop. Conclusive evidence has been recorded to show that these flowers have no attractions for codling-moths.

The fact that many different kinds of moths are often attracted to lights or to alluring baits in large numbers, has led many to believe that the codling-moth could also be lured in sufficient numbers to make it pay to build fires or to place trap-lanterns in an orchard, or to hang sweetened or other baits of various kinds in the trees. Many experiments have been tried along this line by such reliable observers as Riley, Cook, and Atkins, and so few codling-moths were captured as to conclusively show the entire futility of attempting to check the pest in this way. Many collectors of insects also report very few captures of the moth at their lures or at lights. Most of the reported captures of the insect in large numbers at baits or traps are the results of mistaken identity.*

There is one suggestion of considerable importance to be made in this connection. As many of the worms are carried with the fruit into store-rooms in the fall, where they spin their cocoons, consequently the moths often emerge in the spring in considera-

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*The use of baits has recently received considerable attention in Germany and in *Der Praktische Ratgeber*, for 1895, is recorded an account of an experiment with glasses of apple jelly hung in the trees. We glean from the report that quite a number of codling-moths were thus captured, about half of them being females.

ble numbers and escape through the windows and doors. It would be a simple matter to put screens or mosquito netting over all openings during May, June and July, thus effectually trapping the moths which would otheswise find their way to orchards and start a numerous progeny. The number of the moths which sometimes emerge in these fruit-rooms is surprising. Hundreds of cocoons have been found in a single apple barrel, and in one instance in California the openings in a fruit-roon were screened and nearly 16,000 codling-moths were thus trapped and killed between the middle of April and the end of August, nearly 1,000 being caught in a single day, June 15th. It would not be necessary to go to the trouble of catching all the moths in a room thus screened, for they would soon die a natural death.

Can we Kill the Eggs?

It is only recently that anyone has suggested the possibility of reaching the codling-moth in its egg stage. Mr. Card reported from Nebraska in August, 1897, that "the eggs are very easily accessible, being laid as they are on the upper surface of the leaf. In a limited way, in laboratory experiments we have found that kerosene emulsion will destroy these, but we are not yet able to say whether a strength that may be safely used will prove effective in field work." Mr. Washburn seems to have been the the only one to try any other experiments against the eggs. In 1892, he allowed a few apples, upon which eggs occurred, to remain in a solution of one pound of IXL (a mixture of lime, salt, and sulphur), about one pound of whale oil soap, and about an ounce of Paris green, in sixteen gallons of water; subsequently these eggs hatched.

Apple-trees have been sprayed with similar substances. In 1878, Cook sprayed an apple-tree weekly from May 15th till the last of June with a strong solution of soft soap, with the results that not a single apple was wormy, while an unsprayed tree had nearly three-fourths of its fruit infested. Whether the strong smell of the soap kept the moths away, whether the eggs were killed, or how the solution affected the insect is not suggested. Goff has sprayed apple-trees with kerosene emulsion once (June 11th) and with McDougall's Sheep Dip twice (May 25th and 30th) but with little or no effect on the codling-moth.

It may be possible to reach the eggs wtth a spray in Nebraska where they seem to be laid on the leaves, but our experience in trying to kill the eggs of insects leads us to fear that it will take a stronger mixture than the plant will stand to accomplish the desired result. Whether the eggs can be reached as readily when they are laid on the fruit, can be determined only by experiment. On the whole, we doubt if the codling-moth can ever be combated in its egg-stage nearly so successfully and easily as at some other time.

Can we Reach the Pupæ?

As the pupal period lasts only about two weeks, and is passed in the cocoon hidden in some crevice of the bark or in store-rooms, it offers but little opportunity for attack. Many pupæ are killed during the summer when the "banding" system (to be discussed later) is thoroughly carried out. Many of them could also be killed in the spring in storerooms by fumigating the room, as suggested by Wier of California, with carbon bisulphide or hydrocyanic acid gas. But the insect can be just as effectually gotten at while it is yet a caterpillar, or in the fruit-room, even after the moths have emerged; so that although the pupæ can be reached to a limited extent and killed, we can fight the insect much easier and more successfully at some other time.

How to Kill the Apple-worm or Caterpillar.

Having discussed the possible chances of reaching the insect in its moth, egg, and pupal stages, we now turn our attention to combating it in its more vulnerable stage, as an apple-worm. From the time the caterpillar leaves the egg until it is snugly ensconced in its cocoon, it can be reached in several different ways, none of which, however, are a complete success.

Jarring or picking infested fruit from the trees.—The fact that one can often easily detect the wormy fruit soon after the insect has begun work, by the pile of brown excrement thrown out at the blossom end (as shown in figure 133) led several orchardists about 1870 to adopt the practice of jarring or picking off such fruits and destroying them. In 1871, Mr. Chapin, of East Bloomfield, N. Y., reported that by this means he was able to preserve the fruit in an orchard of a hundred acres, at the rate of about an acre an hour, with two men and a boy. The men would knock off the wormy fruit with poles about as fast as the boy could gather them into baskets. This simple expedient would be practicable nowadays in the case of a few trees in a door-yard, but even there equally as successful results can be secured with less labor by other methods.

The destruction of the "windfalls."—Among the earliest recommendations made for the destruction of the codling-moth, both in Europe and in this country, was to destroy all "windfalls" as fast as they fell. Careful experiments by Forbes and Munson have shown that about 82 per cent of these "windfalls" are caused by the codling-moth ; the observations of LeBaron, Beal and Cook led them to conclude that about one-half of the wormy apples which fell still contained the worms ; many have also observed that the worms do not remain long in "windfalls." From these facts one can readily see that the prompt destruction of the "windfalls" would considerably lessen the numbers of the pest, but it could be only partially effective since about half of the worms leave the fruits before they fall. Many have reported good results from pasturing hogs or sheep in orchards to eat the "windfalls," and wherever this is practicable, it would prove a valuable addition to other methods of warfare. In the case of a few choice trees in a door-yard, it would be a good, practicable plan to gather the "windfalls" by hand every few days and destroy them or feed them out to stock.

144.—*The hay-rope band in operation.* (Reduced from Dr. Trimble's picture.)

At best, however, the destruction of "windfalls" can be only partially effective against the codling-moth.

Trapping the worms on the tree trunk, or the "banding" method:—Upon leaving the fruit, the apple-worm preferably seeks the shelter of the crevices and loose bark of the trunk of the tree before spinning its cocoon. This fact was known as early as 1746, but it was not until nearly a century later that Burrelle, of Massachusetts, discovered that thousands of the insects may be obtained "by winding round or hanging any old cloth in the crotch of the trees, from the time they begin to leave the apple till the time the fruit is gathered. I think at present the best remedy would be this : In the fall when the insect has crept into the cloth for winter quarters take the cloth from the trees and put it into an oven hot enough to destroy them." Other orchardists soon recorded similar observations, and finally, as a natural outgrowth of Burrelle's recommendation, Dr. Trimble, after a series of experiments with various "bands" in 1864, devised his famous "hay-rope band." A reduced copy of Dr. Trimble's picture of his hay-rope band in operation is shown in figure 144. In forming an ideal place for the apple-worms in or under which to spin their cocoons this hay-rope band is equal to anything yet devised.

This "banding system" thus thoroughly inaugurated by Dr. Trimble soon became the principal and most successful method of warfare against this pest. It was largely practiced during the decade between 1870 and 1880, in many parts of the United States, especially in Michigan where it is said to have brought about a noticeable improvement in the apples from that state. Extensive experiments have been made since 1869 with bands of various kinds by Riley, LeBaron, Cook, Beal, Chapin, Wickson, Popenoe, Washburn and Card; and within the past three or four years, the banding system has received considerable attention in Germany by Schilling. These experimenters differed in their conclusions as to what was the best band to use. Among those found the most practical and successful may be mentioned common straw wrapping paper, 18x30, folded lengthwise thrice upon itself; rags of any kind; a very effective but rather expensive one was formed by lining one side of an old piece of sacking four inches wide, with strips of lath; strips of old carpet; woollen cloths; old grain sacks cut into strips; felt paper sold for carpet lining; and strips of heavy express paper cut on a slight curvature and folded together once; while Trimble's hay-rope band was found equally effective, it was not nearly so convenient to make or use and was thus early discarded.* Any of the above bands are easily made and quickly applied by placing them around the tree and either putting a tack through the overlapping ends and into the tree or else by simply tying a cord around the middle of the band. To work the most successfully, the tree should be scraped quite smooth where the band is applied; the band should be arranged to present one or more folds in which the worms like to spin their cocoons; and two bands should be put on each tree, one near the crotch and the other near the base, thus offering convenient places for the worms which may come down from the apples on the tree and also for those which may go up from the "windfalls." The bands should be put on in June or about the month after the blossoms have fallen, and they should be kept on until the fruit is gathered. They must be removed and examined every ten days until the latter part of August when it will not be necessary to examine them again until late in the fall, except where more than two broods of the pest occur. All of the cocoons with their living contents must be destroyed at each examination; this can be done either by burning the cheap paper bands and putting on new ones each time, or, in the case of cloth bands, by putting them in hot water or by running them through a wringer. The necessity for this frequent examination of the bands arises from the fact that some of the worms will be changing to pupæ and the moths would soon escape, thus defeating the whole object of the use of the bands. All those who have expressed an opinion after using the bands extensively, state that the expense during the season need not exceed four cents per tree, or that they can be used with decided profit.

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*In 1870 or 1871 there was was patented and put on the market what was known as "Wier's shingle trap." It consisted of three shingles, separated for a slight distance and held together by a large screw through their center, by which they were also fastened to the side of a tree. The idea was that the worms in seeking a place to spin upon the trunk of the tree would be allured to these shingles. The trap could be easily detached from the

In 1887 Wickson carried on an experiment to get at the exact proportion between the worms on a tree and the number caught by bands during the season. He bandaged 457 apple and pear trees at the California Experiment Station, and caught only 1188 worms while 2704 fruits were found from which the worms had escaped; the bands had thus captured only 44 per cent of the worms. The trees were quite smooth, and only one band

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tree and by turning the shingles the insects between them could be quickly crushed. This trap aroused considerable interest at the time, but careful comparative tests by Riley and LeBaron soon showed that it was not nearly so effective as almost any kind of a band which went completely around the tree; and Wier's shingle trap was soon discarded.

was used; doubtless better results would have been obtained by the use of two bands. However, 44 per cent is a good showing, and as Mr. Wickson well says: "the destruction of this proportion of fully fed and healthy larvæ must be considered very satisfactory;" and "it will be seen that this old method of treatment is still one of the most effective that can be employed." The next year a similar experiment was made at the Kansas Experiment Station, but in this case all of the trees were also sprayed with poisons, thus somewhat complicating matters. The record shows that the bands captured only about 8.5 per cent (238,000 infested apples and only 20,398 insects) of the insects which had done the injury; one band was used. and it seems as though there must have been some conditions not mentioned in the record which might explain the great difference between these results and those obtained in California. Yet with even this small per cent of worms captured it was considered that the bands could be used with profit in Kansas.

It is surprising how many of the worms can be captured sometimes under these bands. In 1873, Beal thus entrapped on 211 trees bearing light crops, 6884 of the insects during the season, the largest catch being 1450 on July 18th and the smallest, 210 on August 15th.

Previous to the discovery of the spraying method for combating the codling-moth, this banding system was the most successful method suggested, and as the above facts show, it has been demonstrated that much can be done with bands to reduce the numbers of the pest. Yet under the most favorable circumstances, apparently we cannot hope to capture more than half of the full-grown worms with the bands, and then not until they have done their destructive work. In short, with the bands we simply help to reduce the numbers of the succeeding generations ot the insect, and thus at the best it is only a partial remedy. However, all who have tested it, claim that the method can be practiced with profit, and it is evident that where there are two full broods or more of the insect we must devise something to supplement or take the place of the poison spray. Thus under such circumstances, doubtless the best method of combating the pest, so far as our present knowledge goes, would be to combine the band treatment with that of the poison spray, to be discussed next. Forbes arrived at the same conclusion in his experiments in Illinois in 1885 and 1886, as also did Popenoe, Marlatt and Mason in their Kansas experiments in 1888; and experiments now in progress in Nebraska and New Mexico are along these lines.

Spraying for the Codling-Moth.

Apparently the first suggestion to spray apple-trees to check the codling-moth was recorded in 1850 by Mr. Simpson of Massachusetts (Downing's Horticulturist, IV., 567). By placing a thin plate of bees-wax over the "eyes" of a number of apples, he found that he saved them from attack by the apple-worm. He then reasoned: "But the plan for practical purposes is to syringe the fruit with whitewash; this will fill the eye and thus prevent the moth from laying her egg."

About thirty years later the same idea seems to have been conceived by Dr. Hull, of Illinois. He recommended dusting air-slaked lime over the trees just after the blossoms fell, especially when the dew was on. In 1885, Forbes sprayed some apple-trees eight times with fresh air-slaked lime mixed in water; the results indicated "the uselessness of this substance against the codling-moth." In 1889, Gillette mixed some carbolic acid with plaster and threw this on the trees when the dew was on; two applications were made "with an apparent saving of 34 per cent of the fruit that would have been wormy." He states that as it simply repells the moths from laying eggs and does not kill the insect, it could hardly be recommended even if it gave much better results.

Spraying with poisons.—In 1872, LeBaron recommended fruit-growers to spray their trees with Paris green to check the canker-worms, and this method was soon adopted by many orchardists, some of them using white arsenic instead of Paris green. In 1878, a practical fruit-grower accidentally discovered that when he sprayed his trees with Paris green, he "not only rid the orchard of canker-worms, but that the apples on the sprayed part were much less eaten by codling-moths."*

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* This fact seems to have been first discovered by Mr. E. P. Haynes, then living near Hess Road, Niagara Co., N. Y. Mr. J. S. Woodward had advised him to use the poison for the canker-worms, and in January, 1879, this discovery was reported to the meeting of the Western N. Y. Hort. Society by Mr. Woodward. It seems that the Hon. J. M. Dixon, and others, had also used white arsenic and Paris green for canker-worms in Iowa as early as 1875, but we can find no indications in the contemporaneous horticultural literature that Mr. Dixon realized he had at the same time checked the codling-moth until 1880 (Trans. Iowa Hort. Soc.), or after Mr. Woodward had reported his success and it had been confirmed by the careful experiments of Cook in Michigan. It thus seems that to Mr. Haynes and Mr. Woodward belong the credit of this pioneer work in the discovery of what has proved to be the most successful method of combating the pest yet devised.

The first careful experiments by an entomologist with the poison spray were made in Michigan in 1880 by Cook, who had learned through Mr. Woodward of its successful use in western New York. Cook sprayed twice with London purple and reported the following results in December of the same year: "The trees were loaded with fruit, but careful examination, made August 19th, discovered not a single injured apple. Other apple trees, only a few rods distant, which were not treated with the poisonous liquid, are bearing fruit one-fourth to one-half of which is 'wormy.'" Notices of the successful use of the poison spray appeared in most of the leading agricultural papers, yet comparatively few adopted the method for the destruction of the codling-moth during the next few years. Entomologists were somewhat afraid to recommend it, and orchardists seemed to hesitate in applying poison for this pest, although it was quite freely used for canker-worms. A very few of the most progressive men adopted the method, and with apparently successful results.

In 1885 and 1886 Forbes and Goff made careful and extensive experiments with poison sprays, and the results indicated that at least 70 per cent of the loss commonly suffered by the fruit-grower from the ravages of the codling-moth could be prevented by thoroughly applying the Paris green once or twice in the spring. Similar results were obtained in California by Wickson in 1887. After the establishment of the State Experiment Stations in 1888, a new impetus was given to the adoption of the arsenical sprays, for nearly every Station, sooner or later, reported the results of careful and successful spraying experiments against the codling-moth. Not only has the practicability and effectiveness of the poison spray been demonstrated during the past ten years by the most carefully conducted experiments at nearly every experiment station in the United States, but the thousands of practical fruit-growers who have thoroughly tried it are unanimous in their testimony that from 50 to even 90 per cent, in some cases, of the fruit that would otherwise be ruined by the insect can be saved at a comparatively slight expense. To ensure success it is necessary to understand some of the essential facts in regard to the "whys and wherefores" of the operation which have been brought out at one time and another by the various experimenters during the past ten years.

What poison to use.—Many comparative experiments have been made with the different arsenical poisons (Paris green, London purple, white arsenic, arsenite of lead, etc.) to determine which is the most effective against the codling-moth. In nearly every case the recorded results show a decided advantage in favor of Paris green over all other poisons. At the present time hundreds of tons of it are used in the United States in combating the codling-moth alone. It is less variable in its composition than London purple, and the latter is more liable to injure the foliage, but its cheapness and lightness cause many to use it in preference to Paris green.*

Paris green should be used at the rate of one pound in from 160 to 200 gallons of water, or it can be used even a little stronger when mixed with the fungicide, Bordeaux mixture. Careful experiments by Lodeman, Craig and others have demonstrated that the poison is just as effective against the codling-moth when used in combination with the fungicide as when used alone. When used alone there should be added to the Paris green, but more especially to London purple, about twice as much freshly-slaked lime, to prevent any caustic action on the foliage resulting from the presence of soluble arsenic in the poisons; the lime already in the Bordeaux mixture does this. It is therefore now a common practice among fruit-growers to use the poison (for the codling-moth) in combination with the Bordeaux mixture (for the apple scab fungus), thus "killing two birds with one stone." In mixing Paris green or London purple, it is always best to first wet it up in a small quantity of water, making a sort of thin paste; if the dry poison is thrown directly into a large quantity of water it can not be mixed so quickly nor as satisfactorily.

When to spray for the codling-moth.—The commonly accepted notion that the eggs of the insect were laid in or on the calyx of the fruit soon after the blossom fell, and the fact that a large percentage of the worms enter at this point, led to the recomdation to spray just after the blossoms fell. The experience of those who have sprayed has confirmed this conclusion, and it is now the universal practice to try and make the first application at this time. As Mr. Lodeman has put it: "The falling of the apple blossoms is the signal for the use of arsenites in the destruction of the codling-moth." Our observations would indicate that a safe rule will be to spray the fruit at any time within a week after the blossoms fall; if it rains within a few days repeat the spray at once. The reason why and the great importance of spraying at this time is discussed under the next heading. Where there are both early and late varieties in an orchard, it may be necessary to spray some trees before others; but usually there is not enough difference in time between the dropping of the blossoms from late and early varieties so but what all trees can be sprayed the same day. Although experimenters demonstrated that it was necessary to spray at this time to secure the best results, yet but few really understood the "why" of it; that is, just how it did or could affect the insect when applied at this time.

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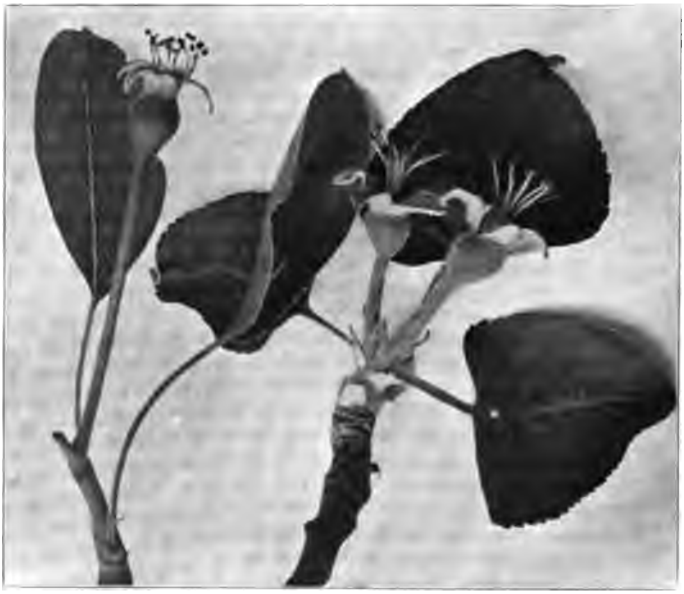
* A "Zoektein Poison" was tested by Goff in 1888 and 1889, and "Climax Insect Poison" in Kansas in 1888, but neither these nor other poisons which have been tested have proved equal to Paris green in effectiveness.

How the poison affects the codling-moth.—Those who critically examine the literature will be surprised to find how few definite statements there are regarding this very important phase of the question of combating this insect. It seems to have been the current notion for some time that the poison spray not only killed some of the insects, but that it also acted as a preventive in some way. It was in consequence of the repeated requests of Mr. Lodeman for information on this point that we began studying this old enemy, about which most of us have thought there was nothing new to be learned. We were surprised to find several times that our observations would not agree with the stereotyped notions regarding the life and habits of the insect at the time when fruit-growers were spraying to kill it. Our first surprise was to find that the moths did not begin to emerge in considerable numbers until several days after the blossoms had fallen, and consequently we were unable to find any eggs until the blossoms had been off for a week or more.

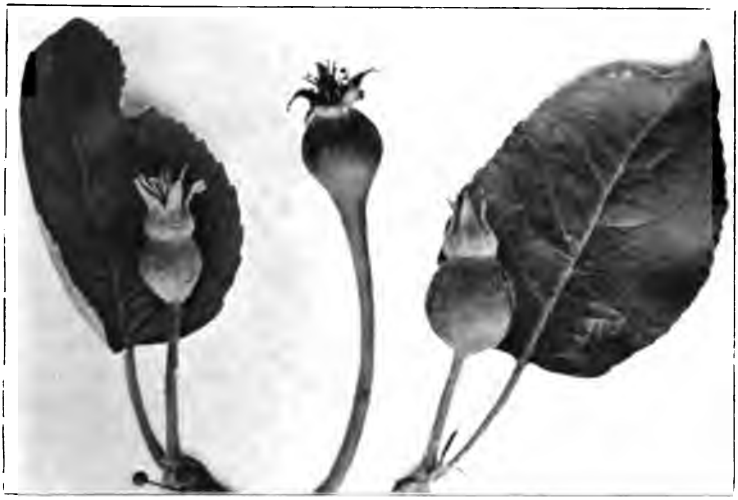
Meanwhile, we had been watching the development of the young fruit and had seen something of great importance to fruit-growers and which seems to have escaped the notice of most experimenters; we have seen no mention of it except by Gillette and Munson. Just after the petals fell, we found the blossom-ends of both apples and pears in the condition shown in figure 145; that is, the calyx lobes were spread widely open, forming a saucer-like cavity. As several complaints had reached us that the codling-moth was not so easily reached on pears as on apples, we watched the developing pears also. The fruit at the left in figure 145, is a pear, and the only difference we could see at the time between it and an apple was that the latter was covered with a coating of fine hairs. At the time we theorized that possibly the Paris green would stick to these "fuzzy" apples better than to the smooth pears, and the worms thus be more liable to get some of the poison on the apple, but this theory was soon exploded by further observations. About a week after the petals fell, we found that the blossom-ends of apples and pears looked like those shown in figure 146; the center fruit is a pear. The calyx lobes on the apples had begun to draw together, and within the next few days the apples presented the appearance shown at *a* and *b* in figure 131; that is, the calyx lobes had drawn completely together forming a tight cover over the calyx-cavity. In the case of the pears, however, the calyx lobes drew together but very little. How this fact may affect the effectiveness of the poison spray for the insect on pears will be discussed later. On most varieties of apples we found the calyx-cavity closed within two weeks after the petals fell. Mr. Card found it closed in about ten days in Nebraska in 1897, but in the case of some varieties of apples it never closed. Munson records that the calyx lobes on the Baldwin closed in about two weeks. The time doubtless varies a few days with different varieties.



145.—*Just right to spray. A pear and two apples from which the petals have recently fallen. Note that the calyx lobes are widely spread.*

Now of what importance to the fruit-grower are these facts regarding the closing of the calyx lobes? Anticipating a little, it means that *the closing of the calyx lobes is the signal that it is too late to get in your most effective blow against the codling-moth with a poison spray.*

Returning to our observations upon the insect, we found no eggs until the calyx lobes had closed or nearly so, as shown at *a* and *b* in figure 131. And as the worms would not hatch until a week later, we were in a quandary to explain how a Paris green spray, applied according to the prescribed rule of "just after the blossoms have fallen," could possibly affect a worm appearing on the apple ten days or two weeks later. Our observations on the development of the young fruit, as just described, led us to theorize that the poison must have lodged in the open calyx cup (see figure 145) and, no rain intervening to wash it out, remained there while Nature proceeded to draw a protecting roof over it (see figure 146) and finally left it securely hidden in the calyx-cavity. Here it was found by a young apple-worm a week or so later.



146.—*Almost too late to spray apples effectively. Note that the calyx lobes are drawn nearly together on the two apples, while on the pear in the center, the calyx-cavity is open.*

We soon found, as have other observers, that from 75 to 85 per cent of the worms which hatch in the spring enter the apples through the blossom-end; and we found also that these young worms got their first, and several subsequent meals, in this calyx-cavity. It then only remained to prove the possibility of there being poison therein which had been left there when the trees were sprayed two weeks before. Fortunately, about the time the worms were hatching, we found some apples which had been sprayed with Paris green and Bordeaux mixture just after the blossoms fell. A careful examination of the calyx-cavity with a lens revealed particles of a bluish color. Were these particles of Bordeaux mixture with their attendant bits of poison? Only the chemist could tell us. We at once carefully removed the calyx lobes and surrounding skin from about 50 of these apples and then submitted only that portion of the apples containing the calyx-cup to our chemist, Mr. Cavanaugh. He soon reported traces of arsenic. The quantity found was scarcely enough to weigh, and it seemed as though it were not enough to kill the little apple-worms. But when one remembers that only four or five gallons of the spray are usually applied to a whole tree, and when this is divided up among the millions of leaves and the thousands of apples on that tree, it is easy to see that the amount of arsenic which a single fruit would get, or even 50 of them, would be exceedingly small. Would it be enough to kill the young apple-worms? Careful experiments have shown that it takes much less poison to kill caterpillars when they are small; and as the young apple-worms are scarcely a sixteenth of an inch in length when they begin feeding in the calyx-cavity, it would take only an infinitesimally small amount of arsenic to kill them.*

The above facts and observations lead us to believe that in applying a poisonous spray soon after the blossoms fall, we deposit some arsenic in the calyx-cavity where Nature kindly takes care of it for us until ten days or two weeks later when the little apple-worm includes it in the menu of his first few meals. Furthermore, this poisoning of these young worms which enter the developing fruit in the spring, seems to be the only way and the only time that the insect is or can be the most successfully reached with the spray; as the worms sometimes eat through into the calyx-cavity from the outside at the base of the lobes, and as some of the poison often lodges here, possibly a few of them get enough poison to kill them at this point. Not enough of the spray can be made to stay on the surface of the fruits then or at any subsequent time to reach one in a hundred of the worms which enter elsewhere than at the blossom-end. Put in another way, the above facts mean that we can hope to reach with a poison spray only those apple-worms which enter the blossom-ends of the forming fruits in the spring. To do this, the application must be made soon after the blossoms fall, when the calyx is open, as shown in figure 145. If we wait a few days until the fruit has reached the condition shown in figure 146, or still later as at *a* and *b* in figure 131, it will be too late. We can conceive of no possible way in which a majority of the 15 or 20 per cent of the worms which enter the fruit at some other point in the spring, and all of the worms of the subsequent broods, can be effectively reached with the poison spray.

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* Munson has figured out how much poison would be liable to stay on one apple, allowing two sprayings of two gallons each to a tree. His figures show that the amount of poison per fruit would be less than 3-1000 of a grain.

Others have made chemical analysis of the blossom-ends of apples, and report no traces of arsenic, but their material was not taken until several weeks after the spraying was done (and it may not have been done when the calyx-cup was open), hence could be of little value to determine the point in question.

Thus, while the spraying method is very effective, it can never prove a perfect panacea, especially where there are two full broods or more of the insect in a season. However, it is a great improvement over the old banding method, for with the spray we kill the worms before they fairly begin their destructive work, thus saving the fruit they would otherwise ruin with an ugly worm-hole. Our observations indicate that the little worms do no feeding on the outside of the fruit except just enough to make a tiny entrance-hole into the flesh or into the calyx-cavity. If it were not for their habit of feeding in this blossom cavity for a few days, it is doubtful if spraying would be nearly so effective as it is. It is thus a remarkable fact how much of our success with a poison spray depends upon this habit of the little worms.*

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* We have never found any dead worms in the calyx-cavity, and thus have no absolute proof that they are killed by the poison there, but Munson has recorded an experiment in Maine which strongly indicates that this is the case. He found that out of 346 wormy fruits borne on sprayed trees, only 133 had been entered by the worms at the calyx, while 213 worms had entered at the side or base ; and out of 449 wormy fruits on unsprayed trees, 252 were entered at the calyx, while only 197 worms entered at the side or base. Thus the relative number entering the calyx was more than doubled in the case of the unsprayed tree. "The only plausible explanation would seem to be that the poison lodging in the calyx, had destroyed the larvæ attempting to enter at that end, while those entering the side or base escaped. The larvæ of the second brood were also exempt."

Never spray a fruit tree when it is in blossom.—You can reach the insect and fungous enemies just as effectively, and in some cases more so, either just before or just after the trees bloom.

How many applications to make.—As has just been shown under a preceding topic, it is necessary to success to get a dose of poison into the blossom-end of the young fruit soon after the petals fall, and before the calyx lobes have drawn together. If no rains occur between the time of spraying and the closing of the calyx lobes, then this one application will be just as effective, we believe, if it is thoroughly done, as half a dozen later applications. The sole aim of the fruit-grower should be to have a dose of Paris green in that calyx-cup when it is covered by Nature. If rains wash out one application, then spray again if there be still time before the blossom-cavity is covered. Usually the recommendation is to spray trees twice, once just after the petals fall and again in a week or ten days, to catch the last worms which hatch.

Many extensive experiments have been made to determine the number of applications it is necessary or profitable to make. In 1885, Forbes made seven and eight applications, and the next year only one and two. His results were equally as satisfactory from the lesser number of sprayings. This is also the conclusion reached by Lodeman and others who have made comparative tests. These results are what we should expect from the life-history and habits of the insect. When the second brood of the worms hatch, the calyx-cavity is securely closed and the apples have turned down, so there is scarcely any chance to lodge the poison where the little worms would be liable to get it before they get into the fruit out of harm's way. Yet some experiments in Oregon indicate that a few of the worms of these later broods can be reached with the spray, and apparently enough of them to lead the experimenter to conclude that even six or seven applications can be made with profit. However, it is the unanimous conclusion of experimenters here in the eastern portion of the United States, where there are only two broods or less of the insect in a year, that two applications are sufficient, one just after the petals fall and a second a week later. No definite date can be set for spraying for the pest, as the falling of the blossoms will vary from year to year in the same orchard.

The important thing for the fruit-grower to do is to watch the blossoming of his trees and the developing of the young fruit, and not depend on anything or anybody else. Simply see to it that there is a good dose of poison put into each blossom-end and that it is not washed out by rains before Nature gets it protected with the closed calyx lobes.

How to spray for codling-moth.—Thousands of fruit-growers annually go through the operation of spraying their orchards, and yet many of them simply waste their time and money, for they only half do it. Every one who sprays, or is thinking about doing so, should read and re-read Professor Bailey's "Notions about the Spraying of Trees" (Bulletin 101 of this Station).

As most of those who have sprayed for this insect have not thoroughly understood the necessity for filling the blossom-end with the poison, there is but little definite evidence as to just how this can best be done. Mr. Card, in Nebraska, has recorded the following pertinent suggestions on this point: "By following the sprayer, I found that ordinarily we do not get the calyx thoroughly drenched. For this reason the spray was made coarser than heretofore, and this seemed to work better, particularly when applied with considerable force. It appeared to be easier to get the poison into the cavity when the lobes were wide open (see figure 145) than when they had begun to close (see figure 146), making a vase-formed receptacle. The leaves increase in size very rapidly after the blossoms fall, so on this account the sooner the spraying is done the more thorough it is likely to be. Were there no danger that the poison would be washed out by rains, the best time to apply it would be immediately after the blossoms fall. The later the poison is applied while the calyx is still open the better."

The expense, or will it pay to spray for the codling-moth.—Your neighbor who has been spraying his orchard for a year or more can the most effectively answer this question for you. In Bulletin 84 of this Station, was recorded the testimony of several fruit-growers on this point. It not only pays to spray thoroughly, but it is a positive necessity in many cases. Read Professor Bailey's remarks on this point in Bulletin 101, just mentioned.

The cost per tree is a trifling matter and will not exceed from 5 to 10 cents for the season, depending upon facilities, rains, etc.

It will be necessary to spray for the codling-moth every year that there is a setting of fruit, for several reasons. Usually there are less enterprising neighbors who do not spray and who thus breed a crop of the moths annually, some of which will find their way into your orchard. The insect breeds readily in wild haws, pears, and some other fruits, so that even when there are no apples in a locality some years, the codling-moth does not lack for food. And especially must one remember that we cannot hope to reach with the poison spray the 15 or 20 per cent or more of the worms which do not enter the fruit at the blossom-end, and these are sufficient to develop a large crop for the next season, where there are two or more broods of the insect in a year.

Is there any danger of poisoning the fruit with the spray, or the stock pastured in sprayed orchards?—No. For several years after the introduction of spraying for the codling-moth, this notion prevented its coming into general use. But to-day one scarcely ever hears the question considered seriously. In 1889, Cook made some experiments in Michigan which effectually settled the question that there is no danger from pasturing stock in sprayed orchards.

> He drenched some apple trees with London purple, used twice as strong as recommended. All the poison which dripped off was caught on a paper and the amount of arsenic on this paper then determined by the chemist. In one case, it amounted to .4 of a grain and in another to 2.2 grains. Although these analyses showed that there was little or no danger, the matter was more fully tested by thoroughly spraying other trees under which was growing some bright and tender grass. All of the grass was cut close to the ground and Professor Cook fed it to his horse; and no injury resulted. The experiment was repeated later with the same result. Next three sheep were kept till hungry and then put in a pen made under another tree which had just been sprayed. All of the grass was eaten with no injurious results. This experiment was twice repeated with the same result. Thus practical experiments confirmed the conclusions of the chemist.

As no poison is usually sprayed on the fruit after it is half grown, the rain and wind would naturally remove the last particle of it before the fruit was picked. Chemical analyses have shown that there was not the slightest trace of arsenic on the mature apples which had been sprayed several times when they were small.

Why the spray may not be so effective on pears.—Several fruit-growers have asked us to explain why they were unable to control the codling-moth on pears as effectively as they do on apples. We can only offer the following suggestions on this point. Our observations on the young pears after the blossoms fall show that the calyx lobes never draw together as they do on most varieties of apples (see figures 145 and 146). While it would thus be just as easy to lodge some poison in the blossom-end of pears, the fact that the calyx-cavity remains open or unprotected would permit the poison to be easily washed out by rains or blown out by winds. Whether the recently-hatched apple-worm has similar habits when born on a pear as it does on an apple, we can not say from observation. Possibly, however, the fact that the calyx-cavity is open, may cause the worms to enter the fruit at once, thus taking but few if any meals in the blossom-end. Thus the fact that it will doubtless be more difficult to keep a dose of poison on pears, owing to the open calyx, may partially explain why it may be more difficult to control the insect on this fruit.

In 1874, Riley recorded that experiments in Illinois had shown that pears were mostly injured by the second brood of the apple-worms. Washburn recently reached a similar conclusion from his observations in Oregon. As it has been shown that we can reach but few of the worms of the second brood on apples with a poison spray, it is evident that a similar treatment on pears would have little effect, providing that most of the injury to pears is done by the second brood of worms. Perhaps we have been spraying too early for the insect on pears. Wherever it does serious injury to pears, it would be well to make some careful experiments with the poison sprays.

Briefly stated, no panacea for the codling-moth has yet been found, but by thorough work by a Paris green spray, we can often save at least 75 per cent of the apples that would otherwise be ruined by the worms. Where more than two broods of the insect occur during the season, as in Kansas, Nebraska, Oregon, New Mexico, and neighboring localities in the West, and in the

South, the poison spray is not so effective, for although 75 per cent of the first brood of worms may be killed with the spray, the few worms left will form a sufficient nucleus for a large and very destructive second or third brood ; in these localities the best that can be advised at present is to supplement the poison spray with the old banding system.

To use the poison spray the most effectually, one must understand that it is necessary to fill the blossom-end of each apple with poison within a week after the blossoms fall, for this is where the little apple-worm gets its first few meals, and it is practically our only chance to kill it with a spray. Watch the developing fruit after the petals fall, and be sure to apply the poison before the calyx lobes close (as at *a* and *b* in figure 131), for while *the falling of the blossoms is the signal to begin spraying, the closing of these calyx lobes a week or two later is the signal to stop spraying.*

While we thus have no new methods to offer, and doubt if anything better than the poison spray will be found for combating this insect, we believe that a better understanding of the "whys and wherefores" of the methods already in use will ensure still greater success with them.

MARK VERNON SLINGERLAND.

BIBLIOGRAPHY OF MOST OF THE MORE IMPORTANT CONTRIBUTIONS TO THE ECONOMIC LITERATURE OF THE CODLING-MOTH.

1635. Goedaerdt. Metamorphosis Naturalis, vol. I., p. 98, fig. 46. Apparently the first published account of the insect. It seems to have escaped notice until 1864, when Werneburg referred to it in his "Beitage zur Schmetterlingskunde." Lister added nothing of importance in his Latin edition of Goedaerdt published in 1685.

1728. Frisch. Beschreibung von Allerley Insecten in Teutschland, part 7, pp. 16–17, pl. x, figs. 1–5. Grotesque and yet quite accurate descriptions of moth and larva; believed it preferred to work in unhealthy or injured fruits. No definite data on life-history.

1736. Reaumur. Mem. pour servir a L'Histoire des Insects, vol. II., pp. 484, 496–499, pl. 38, figs. 11, 12 and pl. 40, figs. 1–10. Good account of work of larva in fruit, and in making its cocoon. Two broods indicated.

1746. Roesel. Insecten-Belustigung, vol. I., part 6, no. 13, pp. 33–37, pl. 13, figs. 1–5. In accuracy of detail and coloring, the hand-painted figures equal, if not excel, any colored pictures of the insect published since. Good account of original observations upon its life-history; thought the newly-hatched larva sometimes entered the fruit beneath the egg-shell, and that the worms sometimes left one apple and went to another fresh one. One brood indicated. All stages, except the egg, well described.

1747. Wilkes. The English Moths and Butterflies, book I., class 1, p. 5, no. 9, pl. 65 (copies of Roesel's figures). Probably the first English account; brief compilation from Roesel. Gave to the insect its name of "Codling-Moth," from the Codling-Tree, which is also figured.

1758. Linné. Systema Naturæ. Ed. X., p. 538, no. 270. *Tinea pomonella*, "Alis nebulosis postice macula rubra aurea." Original description of the insect, when it received its first scientific name.

1791. Brahm. Insektenkalender, vol. II., p. 465. Brief account, with many earlier references. Common and sometimes destructive in orchards; and records its habits in fruit-rooms.

1802. DeTigny. Historie Nat. des Insectes, vol. IX., p. 256. Largely a compilation from Reaumur and Roesel. Says eggs are laid on fruit before petals fall.

1805. Bechstein and Scharfenberg. Natur. der Schäd. Forstinsekten, part III., pp. 753–755. Mostly a compilation from Roesel and Brahm.

1819. Tufts. Massachusetts Agricultural Repository and Journal, vol. V., 364–367. Apparently the first account of the insect in American literature. Previous American writers had credited the plum curculio with the cause of "wormy apples." Records some original breeding experiments by which he was led to conclude that he cause of most of the wormy apples in Massachusetts was a moth, and not a beetle or curculio.

1825. Thatcher. American Orchardist, second edition, p. 116. Records finding the worms on the trunks of trees, and therefore advises scrap-off the rough bark and washing trunks with Forsyth's composition. Apparently the first notice of the insect in horticultural books, and the first one to make any recommendations for controlling the insect.

1830. Treitschke. Die Schmetterlinge von Europa, vol. VIII., pp. 161-163. Many references to earlier literature. Descriptions. Brief compiled account of life-history.

1832. Harris. Discourse before the Mass. Hort. Soc., p. 42. Brief remarks. Article not seen.

1833. "Rusticus." Entomological Magazine, vol. I., pp. 144-146. A very good detailed account of the life-habits of the insect. Eggs laid *in* the calyx cup. One brood. Apparently the first important article in the English literature.

1833. Bouché. Garten-Insekten, pp. 113-114. Brief compiled descriptions and account of habits. All that can be done to control it is to collect and feed out all wormy fruit as fast as it falls.

1837. Schmidberger. In Kollar's Naturg. der schäd. Insecten. (For English translation see Loudon and Westwood's edition of Kollar, pp. 229-232, date 1840). Good general account. Two broods indicated. (He published an earlier and more complete account in his Natur. der Obst. schäd. Insecten, to which we have not had access.)

1838. Westwood. Gardiner's Magazine, vol. XIV., pp. 234-239. Mostly a good compilation from the accounts by Reaumur and "Rusticus.' One brood indicated.

1840. Ratzeburg. Die Forst-Insecten, vol. II., pp. 234-236, pl. 14, fig. 7. Very good general account. Believes there is but one brood in North Germany, and doubts Schmidberger's account of two broods in South Germany.

1840. Burrelle. New England Farmer, vol. XVIII, no. 48, June 3, p. 398. "On the Curculio." Records breeding the moth. One brood only. Apparently the first one to suggest the famous "banding" method.

1841. Harris. Insects of Massachusetts, pp. 351-355. (In the editions of 1852 and 1862, no change occurs.) Very good general account. Only one brood indicated.

1843. Gaylord. Trans. N. Y. State Agr. Soc., p. 158. Brief account with Westwood's figure. Recommends allowing swine to run in orchard. Insect then common in New England, but very rare in the Middle States.

1844. Löw. Schädliche Insecten, pp. 239-241. Largely a compilation from Roesel, with good discussion of remedies.

1845. Downing. Fruits and Fruit-trees, p 66. Brief account.

1846. Morris, Miss. ("Old Lady"). American Agriculturist, vol. V., February, pp. 65-66. Good account, with original observations, and illustrated by what is probably the first original figure of the insect to appear in American literature.

1849. Cole. American Fruit Book, p. 89. Brief account. Reports it numerous in New England and along the seaboard, and becoming more common in the Middle States.

1850. Simpson. The Horticulturist, vol. IV., p. 567. Brief account of breeding experiments. Two or three broods indicated. Discovered that a cloth in the crotch enticed many worms, and after experiments with wax, recommends that trees be sprayed with whitewash to fill blossom-end of fruits and thus prevent egg-laying at this point.

1855. Nördlinger. Kleinen Feinde der Landwirthschaft, pp. 339-346. One of the best and most complete accounts which have appeared in the German literature. Very good discussion of remedies. Believes it is single-brooded in Germany.

1859. Jaeger. The Life of N. Am. Insects, pp. 179-181. Brief, quaint account.

1861. Goreau. Insects Nuis. aux Arbres Fruiters, pp. 118-121. Very good general account. One brood in France.

1865. Trimble. Treatise on the Insect Enemies of Fruit and Fruit Trees, pp. 103-139. Three full-page colored plates. One of the best accounts in the American literature. Detailed notes on birds as enemes of the insect; "hay-bands" devised and experiments recorded. Bred two broods at Newark, N. J.

1867. Boisduval. Essai sur L'Entomologie Horticole, pp. 560-563. Fairly good general account. One brood.

1868. Walsh. Report on Insects of Illinois, pp. 27-29. Arguments for two broods in Illinois.

1868. Walsh and Riley. American Entomologist, vol. I., pp. 3-6. Evidence in favor of allowing hogs to run in orchards.

1869. Walsh and Riley. American Entomologist, vol. I., pp. 112-114. Very good general account, illustrated by Riley's well-known figures. Two broods.

1869. Riley. First Missouri Rept. on Insects, pp. 62-67. Good general account. Two broods.

1870. Riley. American Entomologist, vol. II., pp. 321-322. Records experimental proof of two-broods in latitude of St. Louis, and discusses hay-bands vs. rags for trapping the worms.

1871. Taschenberg. Ent für Gärtner und Gartenfreunde, pp. 310-313. Good general account. Admits but one generation in Germany. (The same account occurs in his Prak. Insektenkunde, III., pp. 228-231, date, 1880.)

1872. Riley. Fourth Missouri Report, pp. 22-30. Good discussion of bands, Wier's Trap, lights, jarring, and the enemies of the insect.

1873. Riley. Fifth Missouri Report, pp. 46-52. Records careful experiments with different traps on trunk, and the discovery of two parasites.

1873. LeBaron. Third Rept. on Insects of Ill., pp. 167-185. One of the best accounts in the American literature; based largely upon original observations.

1875. Cook, A. J. Rept. Mich. Pomol. Soc. for 1874, pp. 152-160. One of the best accounts in American literature, largely based upon original observations. Records seeing the eggs, but does not describe them.

1875. Saunders. Rept. Ont. Ent. Soc. for 1874, pp. 43-50. Good general account, largely complied from LeBaron and Riley's writings. Two broods in Canada.

1879. Woodward. *Rural New-Yorker*, Feb. 8 (Proc. West. N. Y. Hort. Soc. for 1879, p. 20). First published account of successful use of poisons (Paris green) against the codling-moth.

1880. Cook. American Entomologist, vol. III., p. 263. Also published in 1881 in Proc. Am. As. Ad. Sci. for 1880, p. 669; and in Rept. Mich. Hort. Soc. for 1880, p. 136. Records the successful use of London purple to destroy the insect; first test of poisons made by entomologists.

1881. Cooke. Insects Inj. to Cal. Fruit and Fruit Trees, pp. 13-19. One of the best discussions of the habits and methods of fighting it in our literature. (Practically the same account was published by the author in 1879, and again in 1883 in his book on "Injurious Insects," pp. 102-108). Three broods indicated.

1881. Schmidt-Göbel. Die Schäd. und Nütz. Insecten, pp. 121-122. Brief general account.

1883. Walton, Miss. Report Iowa Hort. Soc. for 1882, pp. 199-203. Good general account, with some valuable breeding experiments.

1883. Chapin. Rept. 2d An. Conv. of Cal. Fruit Growers, pp. 17-25. Detailed account of an extensive experiment with bands and gathering infested fruit; over 15,000 moths caught in a fruit-room in one season.

1883. Saunders. Insects Injurious to Fruits, pp. 127-133. Very good general discussion.

1884. Atkins. Rept. Maine Bd. of Agriculture for 1883, pp. 356-363. One of the most important contributions to the American literature; it is based entirely upon original observations. One full brood and a partial second one indicated.

1885. Girard. Traité, D'Entomologie, vol. III., pp. 714-716. Good general account. One brood.

1886. Goff. Fourth Rept. of N. Y. Agr. Expt. Station, 1885, pp. 246-248. Records one of the first carefully conducted experiments with Paris green

1886. Forbes. Trans. Ill. Dept. of Agr. for 1885, Appendix, pp. 26-45. Records one of the first and most carefully and scientifically conducted experiments with poison and lime against the insect. Eight applications made.

1886. Whitehead. Rept. on Insects, prepared for Agr. Dept. of Great Britain, pp. 62-67. Good general account.

1886. Crawford. Rept. on Insect Pests in S. Australia, pp. 32-39. Good general account.

1887. Forbes. Bulletin No. 1, Office of State Ent. of Ill., 26 pages. Results of scientific experiments with Paris green, London purple, and arsenic in 1886. Comparison of 1, 2, and 3 applications. Three broods indicated.

1887. Wickson. Bull. 75, Cal. Agr. Expt. Station. Careful comparative experiments with bands and spraying.

1888. Howard. Rept. U. S. Dept. of Agr. for 1887, pp. 88-115. The best and most exhaustive discussion of the insect in the literature; and from it have been compiled most subsequent discussions of habits and life-history. Colored plate.

1888. Cook. Bull. 39, Mich. Expt. Station, pp. 1-4. Results from 1, 2, and 3 sprayings, and general conclusions from 8 year's experimenting with poisons.

1888. McMillan. Bull. 2, Nebraska Expt. Station, pp. 68-77. Very good general discussion of habits and especially of remedies.

1889. Pissot. Le Naturaliste, p. 60. Notes on metamorphosis, with detailed account of cocoon. Two broods indicated.

1889. Gillette. Bull. 7, Iowa Expt. Station, pp. 270-280. Very important and careful experiments with poisons and carbolic acid. Two broods.

1889. Popenoe, Marlatt and Mason. First Rept. Kansas Expt. Station, pp. 165-193. Valuable record of careful experiments with poisons and bands, including tables giving dates of blossoming of many varieties of apples.

1889. Tryon. Rept. on Insects and Fungous Pests (Queensland, Australia), no. 1, pp. 43-49. Very good general account.

1890. Bos. Tierische Schäd. und Nüzlinge, pp. 526-527. Brief account.

1890. Cook. Rept. Mich. Bd. of Agr. for 1889, p. 320. Experiments to show that grass under sprayed trees may be safely fed to stock.

1890. Ormerod. Manual of Injurious Insects, pp. 286-290. Brief general account.

1890. Olliff. Agr. Gazette of New South Wales, vol. I., pp. 3-10. Very good general account.

1890. Koebele. Bull. 22, Div. of Entomology, U. S. Dept. of Agr., pp. 89-93. New and important observations upon the habits of the moth, the eggs, and the enemies of the different stages of the insect.

1891. French. Handbook of Dest. Insects of Victoria, part 1, pp. 45–55. Excellent general account; colored plate.

1891. Gillette. Bull. 15, Colorado Expt. Station, pp. 4–18. One of the best and most accurate general discussions of habits and remedies.

1891. Washburn. Bull. 10, Oregon Expt. Station, pp. 1–16. Valuable record of careful experiments with poisons and bands.

1891. Beckwith. Bull. 12, Delaware Expt. Station, pp. 16–23. Comparative test of Paris green and London purple, showing slight advantage for the former.

1892. Munson. Rept. Maine Expt. Station for 1891, pp. 99–109. Careful experiments with poisons and important deductions therefrom.

1892. Lodeman. Bull. 48, Cornell Expt. Station, pp. 268–274. Results of careful experiments with combination of poisons and Bordeaux mixture.

1892. Thompson. Handbook to the Insect Pests of Farm and Orchard (Tasmania), part I, pp. 34–54. Excellent general account; two broods.

1892. Kellogg. Common Injurious Insects of Kansas, pp. 78–80. Good general account.

1892. Treat. Injurious Insects, pp. 161–163. Brief general account.

1893. Washburn. Bull. 25, Oregon Expt. Station, pp, 1–8. Record of original observations which form one of the most important and accurate contributions to the literature of the habits of this insect yet made. The egg figured for the first time.

1893. Lodeman. Bull. 60, Cornell Expt. Station, pp. 265, 273–275. Experiments to show that usually two applications of poisons are all that are necessary or profitable in New York.

1893. Riley. Bull. 23, Maryland Expt. Station, pp. 71–77. Very good general account of habits, remedies, and especially of its enemies.

1893. Lintner. Ninth Rept. on Insects of N. Y., pp. 338–342. Detailed account of the work of the second brood of larvæ in N. Y.; and a discussion of the prevalent ideas regarding the egg-laying habits of the insect.

1893. Coquillett. Bull. 30, Div. of Ent. of U. S. Dept. of Agr., pp. 30–33. Notes on life-history, supposed enemies, and methods of combating the insect in California.

1894. Smith. Entomological News, vol. V., pp. 284–286. Records breeding experiments which indicate but one brood of the insect at New Brunswick, N. J.

1894. Marlatt. Insect Life, vol. VII., pp. 248–251. Evidence from various sources to show that insect is usually double brooded.

1894. Schilling. Der Praktische Ratgeber, Vol. 9, pp. 121–123; 133–135; 141–143. The best discussion of the insect from a practical and economical standpoint in the German literature. One brood.

1894. Sempers. Injurious Insects, pp. 57–59. Brief general account.

1895. Marlatt. Proc. Ent. Soc. of Wash., vol. III., pp. 228-229. Suggests that Merriam's life-zones may explain and determine the variation in and number of broods of the insect.

1895. Goethe. Bericht d. Kgl. Lehr. für Obst. Wein, und Gartenbau, pp. 22–25. Records original observations (from breeding-cage experiment) on the egg and on the habits of the young larvæ, with illustrations and descriptions. First definite account of these phases of the insect to appear in any foreign literature.

1895. Weed. Insects and Insecticides, Second Edition, pp. 88–89. Brief general account.

1896. Lounsbury. Rept. Gov. Ent. for Cape of Good Hope, for 1895, pp. 33–36. Brief account.

1896. Bos. Tijdschrift over Plantenziekten, vol. XII., pp. 52–74. Very good account compiled from the writings of Schilling and Goethe.

1896. Slingerland. Michigan Fruit Grower, vol. V., p. 8. Paper read before Mich. State Hort. Soc. Detailed account of original observations on oviposition and the habits of the young larvæ, resulting in the discovery of some new and important economic facts. (The paper also appears in Rept. Mich. Hort. Soc. for 1896, and that portion of it relating to the codling-moth in the *Rural New Yorker* for Jan. 30, 1897, p. 67; and in the Proc. West. N. Y. Hort. Soc. for 1897, pp. 28–30.)

1896. Lodeman. The Spraying of Plants, pp. 252–255. Good general account.

1896. Smith. Economic Entomology, pp, 322–323. Good general account.

1897. Card. Garden and Forest, vol. X., pp. 302–303. Detailed account of original observations on egg-laying and the habits of the young larvæ in Nebraska. Eggs laid mostly on the leaves, and two broods, at least, indicated.

1897. Smith. Garden and Forest, vol. X., p. 334. Notes peculiar differences in habits of the insect in N. J. and especially at New Brunswick, N. J.

1897. Del Guercio. Bulletino della Soc. Ent. Italiana, pp. 12–17. Very good general account.

1897. Card. Bull. 51, Nebraska Experiment Station, 39 pages. Interesting, original observations on the eggs and habits of the young larvæ, with record of experiments against all stages of the insect.

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Professor James Law,	Veterinary Science.
Professor J. H. Comstock,	Entomology.
Professor L. H. Bailey,	Horticulture.
Professor H. H. Wing,	Dairy Husbandry.
Professor G. F. Atkinson,	Botany.
M. V. Slingerland,	Entomology.
G. W. Cavanaugh,	Chemistry.
L. A. Clinton,	Agriculture.
B. M. Duggar,	Botany.

OFFICERS OF THE STATION.

I. P. Roberts,	Director.
E. L. Williams,	Treasurer.
Edward A. Butler,	Clerk.

In pursuance of the provisions of Chapter 128 of the Laws of 1897, several persons were appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work reqnired.

See Bulletin 146, Report of Progress.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.

CORNELL UNIVERSITY, ITHACA, N.Y., February 12, 1898.
THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY, N.Y.

Sir: This account of the investigations carried on throughout the state and at Ithaca in the cultivation of the sugar beet, together with the results of more than four hundred analyses of beets from nearly as many plats, is submitted for publication under Chapter 128 of the Laws of 1897.

In the spring of 1893, seventy packages of sugar beet seed were sent to as many farmers with the view of making a preliminary test of soil and climate in various parts of the state. By this means it was hoped that some information might be secured which would be of value should the culture of sugar beets be introduced. Thirty-one farmers who received the seed responded by sending samples of beets for analyses, and some data as to yield, growth and soil.

The average weight of beets sent for analyses was 830 grammes, and the average per cent of sugar 12.9. The typical sugar beet should weigh about 600 grammes and contain not less than 14 per cent of sugar. Notwithstanding the large size of the beets, due without doubt to too thin seeding, the sugar content was equal to the average of many European sugar beet districts. It should be stated that many of these test plats of beets were in localities where the soil was not well adapted to their growth.

In 1894 another attempt was made to carry forward the work, but there was so little interest in beet culture it was decided to temporarily drop the work.

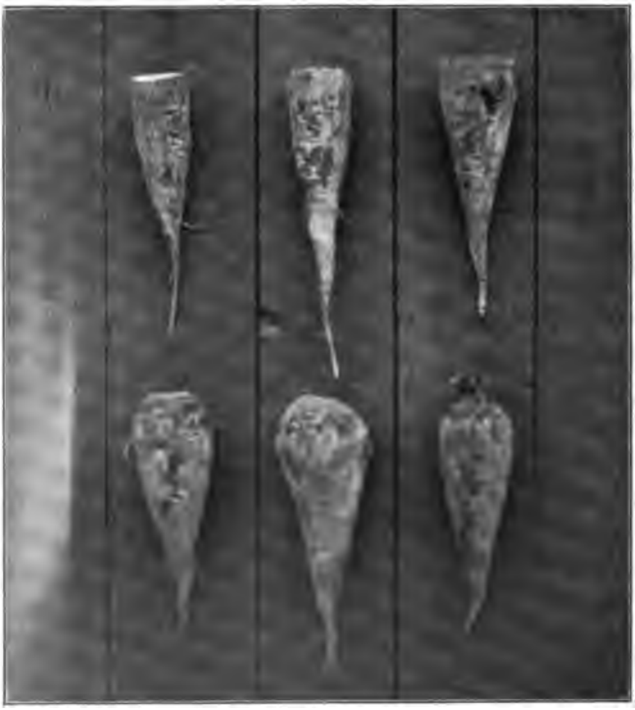
During the winter of 1896–97 the subject of sugar beet culture was again brought up and discussed, and it was decided to resume our investigations. The Department of Agriculture, at Washington, gave its hearty support to the work and sent to the Station five hundred pounds of Kleinwanzlebener beet seed and appointed the Director of the Station special agent in sugar beet investigations.

We found the farmers ready to undertake the work of testing the soil and climate by planting small plats of beets, and to follow the printed instructions which were sent with the seed. Some public spirited farmers bought, and in some cases distributed to their neighbors, packages of seeds. The beets from these plats, when sent to us, were also analyzed. While some data as to soil and tillage accompanied these beets, the information secured could not be as accurate as was that secured by members of our staff who visited the plats under our control and helped to harvest the beets, measure the land and select samples for analyses.

This bulletin, which has cost so much thought and labor, is written in two parts: Part 1st treats of soils, tillage and character of beets; Part 2d gives somewhat in detail the results of the analyses of beets and some of the by-products of the factory, together with notes related thereto.

It is not the purpose to express any opinion as to the wisdom of encouraging the sugar industry in this state by granting a small bounty to the producers of beets. But if it is deemed wise to grant such bounty, it should be based on the per cent of sugar which the beets are found to contain when delivered at the factory, thereby securing a double benefit—increase in production and improvement of quality. A competent chemist for each factory should be appointed by the State to determine the per cent of sugar of each consignment of beets, and his report to his superiors should be final.

I. P. ROBERTS, Director.



147.—*Properly trimmed beets in upper row, improperly trimmed in the lower row. See p. 508.*

SUGAR BEET INVESTIGATIONS.

PART I. FIELD WORK.

1. GENERAL REMARKS ON SUGAR BEET CULTIVATION.

(*By J. L. Stone.*)

The successful manufacturing of sugar from the beet root in America is no longer in doubt. That question has passed the experimental stage. It has been thoroughly demonstrated that American enterprise can secure the necessary skill and machinery either by importation or home production, to successfully manufacture from beets a high grade of sugar.

A beet sugar factory, however, without an abundant supply of good beets is sure to be a financial failure. No matter how well planned nor how carefully constructed the factory is, nor how thoroughly informed and skillful in all the intricate processes of sugar making the management may be, if the farmers cannot or will not produce the beets to profitably employ the machinery and skill provided, the enterprise must languish. Early efforts to introduce the beet sugar industry into America failed for want of beets rather than for want of knowledge and skill in the manufacture of sugar. A number of the factories now in successful operation in this country passed through several "campaigns" before the farmers had become sufficiently interested and skillful to produce a sufficient quantity of good beets to enable the factories to be operated at a profit. At the present time these same factories are unable to handle all the beets that the farmers of their localities desire to grow. It has been demonstrated that beets sufficiently rich in sugar for profitable manufacture can be produced in large quantities in a number of our western states. That the yield per acre is sufficiently large to make the growing of the beets profitable at the price paid, is proven by the fact that the older factories, in some cases, find it necessary to limit the area the farmers are permitted to grow. The farmers in the vicinity of these factories have been prosperous through the recent hard times and land values have advanced while over the country in general land has declined.

Investigations conducted in New York by this Station during the past season (1897) seem to indicate that the state is not behind any of the western states in adaptation of soil and climate to the production of sugar beets.

Examinations of 495 samples of sugar beets grown in 24 counties in the state were made this season. The result shows a juice averaging 16.91 per cent sugar and 83.5 quotient of purity. A portion of each of 272 plats was carefully measured and the product weighed, the result indicating an average yield of 16.95 tons of trimmed beets per acre. See Figs. 147, pp. 492, also table pp. 530.

For purposes of comparison results obtained in other states are given. The Chino factory, Cal., reports as an average of five years' operations, a crop of 9.33 tons per acre, containing 14.2 per cent sugar. The Lehi factory, Utah, reports for the same period an average yield of 9.56 tons per acre, 12.1 per cent sugar in beets and 80.2 quotient purity (see bulletin 55 Wisconsin, p. 12). In Nebraska, about 10,000 analyses show an average of something over 14 per cent sugar while ordinary yields are from 10–12 tons per acre. (Myrick's Sugar, p. 54.)

In each of these states the industry is successfully established. Other states that are not producing sugar have studied the adaptation of soil and climate to sugar beet growing and some of the results are added. Ohio reports that beets grown on 49 farms in 19 counties, juice averaging 12.95 % sugar and 77.2 quotient of purity*.

Wisconsin reports that beets grown on 517 farms in 59 counties in 1890–1892 averaged 12.44 % sugar in juice and 76 quotient of purity†.

Washington State reports that 1544 analyses of sugar beets showed an average of over 15 per cent sugar in juice and 84 quotient of purity‡.

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*Ohio bulletin 75, p. 18.

†Wisconsin bulletin 55, p. 20

‡Washington bulletin 26, p. 5.

NOTE. The figures given for California, Utah and Nebraska are per centages of sugar in beets and are not strictly comparable with the others which are percentages of sugar in juice. To make the figures comparable divide the percentages of sugar in the beets by .95 and the quotient will be the percentage of sugar in the juice.

The French "Journal of Sugar Manufacturers" states that the average yield of beets in Germany is 15 tons and in France 11.13 tons per acre. Many more cases might be added but these are sufficient for comparison.

The question at once arises whether the results obtained on our experimental plats this season represent approximately what the farmers of the state may expect to do when growing a commercial crop. All very well know that it is easy to select a small piece of rich land and by giving it extra care to grow a crop that will far exceed in yield what can be obtained on larger areas.

It is not believed that the results obtained need be discounted on account of these considerations. In the first place the farmers were inexperienced with the crop and did not know the conditions most favorable to its growth. Brief instructions were sent out from this office but more than half of the farmers either did not receive them or paid no attention to them. Some of the plats were on well selected land, the beets grown at appropriate distances and given good culture; but in more cases one or more of these conditions were wrong. Many plats were planted the same as potatoes, three feet or more between rows. Necessarily the result was either a low yield of beets or a larger yield of overgrown beets with a lower percentage of sugar. See page 567. In August and the first part of September members of the station staff visited and inspected 249 of the experiment plats and found a large proportion of them needing cultivation and weeding. The rainfall in July was excessive (see page 567), and for several weeks, just when the farmers should have been actively engaged cultivating their crops, they were not able to get on the land. The weeds grew apace and when the soil was fit to till the farmers were so pressed with their regular work that the beets, being a side issue, were very generally neglected.

The wet July was followed by a severe drought in September and October; the soil baked very hard and conditions were unfavorable. Notwithstanding these seemingly adverse conditions the average yield as given above is very satisfactory. Again in October agents of the Station went to many of the farms and helped to harvest and weigh beets from 178 plats. The beets were washed and trimmed, as required by the factories, before weighing, so it is known that the estimated yields, in these cases at least, were correctly made. Instructions for harvesting and estimating yields were sent to those farmers whom it was found impracticable to reach in person. So there scarcely can be any over estimate as to the yields actually obtained on the experimental plats.

The percentage of sugar and the quotient of purity are also unexpectedly high. It is known that some seasons are more favorable to a high quality of beets than others, and perhaps the past season, notably dry in August, September and October, produced beets of more than normal richness. It will not be surprising then if the high quality of beets secured this season is not maintained in the future with different weather conditions while beets are maturing, but it is believed that the falling off will not be sufficient to reduce the quality below the point of profitable manufacture.

So far as soil and climate are concerned it seems to be settled then that New York State is well adapted to the commercial growing of sugar beets. The question of greater importance remaining for discussion is, will the farmers of the Empire State grow the beets in sufficient quantities, and send them to the factories in such condition as to make the manufacture of sugar profitable?

Agriculture has shared in the general depression of recent years, and farmers are anxiously asking what crop can be grown with a fair chance of profit. The present interest in the sugar industry, therefore, seems to be opportune, and farmers are much more likely to put forth the necessary effort to become skillful in the production of sugar beets than if other crops were paying well.

The sugar beet is an exacting crop and persons unfamiliar with the best methods of growing it have much to learn, and will make many mistakes that will cut down the profits. With a view of helping those who are thinking of growing beets for the factories the following simple instructions have been prepared. These instructions are based partly on our own investigations and partly on the statements of others who have had large experience both as experimenters and practical growers.

Soil.—Sugar beets can be grown successfully on quite a variety of soils—gravelly loam, sandy loam, loam and clay loam—though a sandy loam is usually considered best suited to the crop. Any soil that is well adapted to potatoes will raise sugar beets. While the industry is in its infancy in the state it is wise to select only those soils that are believed to be well adapted, and that are in a high state of fertility, and, so far as possible, are free from foul weeds.

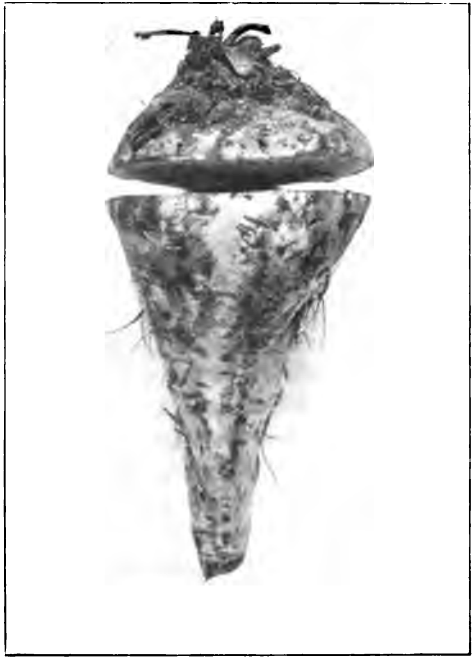
So many things are to be learned regarding the growing of the crop that it is well to encounter as few difficulties as possible at first and take up the more difficult cases later.

Subsoil.—Sugar beets should have a deep soil with a moderately porous subsoil. A shallow soil with a hard or water soaked subsoil is fatal to the crop. If the soil is not right in these respects it may often be made so by thorough drainage and subsoil-plowing. In fact land that is naturally quite unsuited to beet growing may, by these means, coupled with the growing of deep rooted plants, like the clovers, have its character so changed in a few seasons as to become excellent beet land.

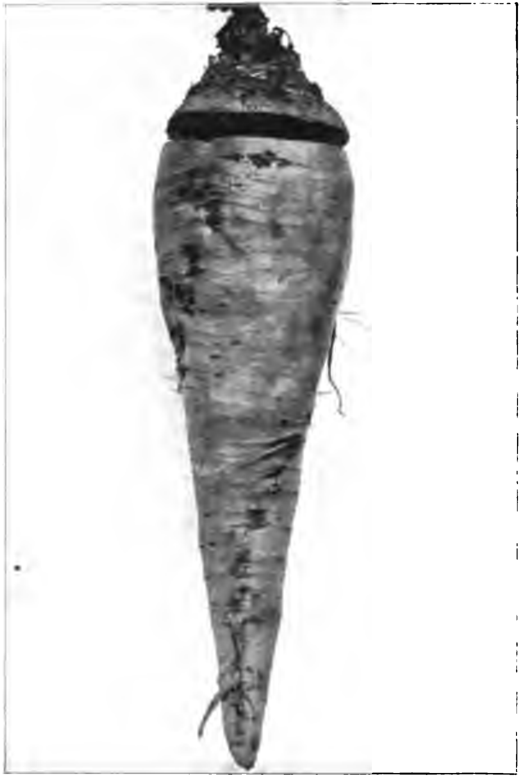
Preparation of the soil.—The necessity of deep plowing cannot be emphasized too much in this connection. The sugar beet should bury itself in the soil the same as a parsnip, and it will do so if the soil conditions are right. If, however, the sub-surface soil is hard or saturated with water the tap root cannot penetrate into it, or if it does get down fairly well, it cannot expand freely in the hard soil, but expands in the direction of least resistance, which being upwards the result is a short root, a considerable portion of which grows above the surface of the soil. This form of beet is objectionable not only because the yield is necessarily less than with long, well formed roots, but the beets are very much less valuable for sugar making.

It is found that the upper portion of the beet, especially that part that grows above ground, is less rich in sugar than the part growing well in the soil, while this same part is highly charged with impurities that interfere seriously with the manufacture of sugar.

The factory people aim to keep the impurities down by requiring that the portion of the beet growing above the surface of the ground be cut off. The aim should be to so prepare the land



148.—*Thirty-three per cent. waste in trimming. Result of growing beets in improperly prepared soil.*



149.—*Fifteen per cent. waste in trimming. Grown in properly prepared soil.*

that the root can bury itself well in the soil. Thus will be secured not only a larger yield, but a smaller percentage of waste in the crown removed. See figs. 148 and 149. Deep plowing is therefore essential, and except where the subsoil is very porous it should be loosened up with a subsoil plow. In those localities where sugar beet growing is established the practice of subsoiling has become general.

It is best to plow the land deeply in the autumn, setting the plow to turn up an inch or two of new soil. The action of the winter's frosts will ameliorate this soil and render it fit for crop growing. Follow the ordinary plow with a subsoil plow, breaking up, but not throwing on top, several inches more of the hard soil. The earth should thus be stirred to a depth of twelve to fifteen inches. This fall treatment is desirable on several accounts. It permits the turning up of more new soil than would be safe in the spring. It secures the more complete decomposition of any coarse vegetation that may be on the land. It breaks up the compactness of the soil so that it can receive the winter's rain and store it for the next season's crop. Opportunity is given for the re-establishment of the capillary action in the soil which was disturbed by deep plowing, enabling the plant to draw from the deeper reservoirs of moisture during the dry season.

It is not advised to plant sod land to beets, but if necessary to do so, it should be fall plowed to give time for the decomposition of the sod, the settling of the soil and the re-establishment of capillary action. It should be plowed deep so as to have plenty of loose earth for a seed bed without disturbing the decaying sod. Sod land will probably suffer more from drought than other, but with plenty of moisture it will grow large crops of beets, which, however, may be low in sugar and in purity on account of too much organic matter in the soil. For the same reasons it is best to apply barn manure to the preceding crop rather than to the beets, but if used on the beet land it should be applied in the fall and plowed under. The influence on the quality of beets of an application of manure applied to the land the same season the crop is grown as compared with the same applied the previous year is shown in the following table which includes all the plats thus reported :

QUALITY AS AFFECTED BY BARN MANURE APPLIED IN '96 AND '97.

	No. of plats.	Average per cent of sugar in juice.	Average quotient of purity.
Manured in 1896	45	17.37	83.96
Manured in 1897...............	59	16.62	82.94

Another effect of the direct application of barn manure is the tendency to produce ill-formed beets as shown in figures 152 and 153 page 507.

Commercial fertilizers may be applied in the spring, but they should be thoroughly incorporated with the soil. Observations made this summer lead to the belief that commercial fertilizers applied on the surface have a tendency, like recently applied barn manure, to cause the development of "fingers and toes," as the ill-shaped sprangly roots are called. It is reasonable to suppose that the plant finding its food near the surface would throw out branches at this point. No doubt this tendency would be most marked in very poor soils and in dry seasons.

If the land is not plowed in the fall then plow deeply in early spring taking care not to turn up much new soil. In the Western States experience has taught that subsoil plowing in the spring is an unsafe practice. If abundant rains do not come after the plowing is done, to compact the soil and re-establish capillary action the crop may suffer more from drought than it will be benefited by the loosening of the subsoil. It would seem that in this state there would scarcely occur a season when there would not be sufficient rainfall after *early* plowing to properly compact the soil before the dry weather of summer sets in. As early in the spring as the land is fit it should be harrowed down and left for a week or ten days that the weeds may have a chance to start, when they will be easily killed by another working. If this operation can be repeated several times before seeding, the crop will be kept clean during the season with much less labor.

The seed bed should be thoroughly prepared. The subsurface should be fairly well compacted; the surface fine, level and free from obstructions to cultivation. It is very important that a good stand of plants should be secured and this is much facilitated by a properly prepared seed bed, but just what tools to use and how much to use them will depend upon the character of the soil and the season.

Seed.—It is of prime importance that first class seed be used. The modern sugar beet is the result of a vast amount of painstaking care and labor in its selection and growth and is a highly artificial product. It therefore quickly deteriorates when the conditions favorable to the maintainance of its high qualities are wanting.

In Europe the production of high class seed is relegated to skillful seedsmen who have made the industry a life study. Little effort has been made in America as yet for the production of seed, our supplies being drawn largely from Germany and France. The matter of selecting the varieties and importing the seed is usually left in the hands of the factory management. There are a large number of varieties possessing somewhat different characteristics and adapted to different classes of soils. Some are noted for their high percentage of sugar, but are light croppers, and are best suited for those localities where the tendency is to grow too large a crop of coarse beets low in sugar. Others are better croppers but not so high in sugar, and are adapted to soils where the tendency is to produce too light a crop of very rich beets. The Vilmorin and the Dervaux are among the very rich varieties but are rather light croppers; the Kleinwanzlebener, the Dippe and the Metta Kleinwanzlebener are among the medium croppers with a good percentage of sugar, while the Deprez and the Eloir are heavy croppers but rather low in sugar. The Kleinwanzlebener and the Vilmorin have been most grown in this country, and seem to be best adapted to our soil and conditions.

Seeding.—For good results it is very necessary to get a good stand. Without it the yield will be unsatisfactory and many of the beets, having too much room, will be overgrown, resulting in a low percentage of sugar and purity.

It is customary to sow about twenty pounds of seed per acre, though if it all grows this is many times more than is needed.

If dry weather follows the planting, only the best of the seed will germinate, if a crust is formed before the plants are up, they help one another to break through, hence the chances are much better for getting a good stand with heavy than with light seeding.

A machine that will drop with accuracy three or four seeds in a place at such distances apart as experience shows is best for different soils, will not only save seed, but will tend to secure an even spacing of the plants in the row and greatly reduce the labor of thinning and weeding. In heavy or damp soils the seed should not be covered more than one-half to three-fourths of an inch, in light dry soils one to two inches. The soil should be firmed over the seed, the degree to be determined by its character, light soils requiring more compacting than heavy ones. On most soils best results are obtained by planting in rows from eighteen to twenty-two inches apart. If the rows are much farther apart than this the beets cannot use all the space and the yield is lessened, or if a good yield is secured it is by growing large beets at the expense of quality.

Such narrow rows, however, are difficult to cultivate except for those accustomed to the work and having machinery especially designed for it. When the ordinary implements of tillage are to be used it would seem wise to allow more room for working between the rows, say twenty-four to twenty-seven inches, and leave the plants a little closer in the rows. Those who expect to till considerable areas of beets will do well to provide themselves with special seeders and cultivators. These seeders are made to sow either two or four rows at a time, and they may be adjusted to sow 16, 18 or 20 inches apart, spacing them very accurately. The cultivators work either two or four rows at a time and are accurately adjusted to follow the seeder, the workman confining his attention to one row while the machinery adjusts itself to the others. Of course such a cultivator can only be used to work rows that are accurately spaced by a special seeder.

Those who have both the special seeders and special cultivators may find it advantageous to adjust the machines so as to sow two rows at either side sixteen or eighteen inches apart and leaving a space of twenty-four or more inches at the centre in which the horse can travel easily while cultivating—the cultivator being adjusted the same as the seeder.

Tillage.—Under certain conditions of soil and weather a weeder can be used with very great satisfaction for the first working of the land after seeding, but those conditions are not always present. Should a heavy rain cause a crust to be formed and the soil again get dry enough to work before the seeds have thrown out many sprouts, the weeder can be used with great benefit to break the crust and destroy small weeds that start quicker than the beet seed. Again, on rather light land that is quite free from small stones and other impediments to tillage, if the plants have come up quite thickly the weeder can be used very advantageously to stir the soil in the rows, thin the beets somewhat, and destroy many small weeds.

Regular cultivation should begin as soon as the rows can be followed, and repeated as often as necessary to keep the surface loose and prevent weeds from gaining a foothold. Under ordinary circumstances tilling fortnightly will probably give as good results as tilling weekly, but whenever a crust has been formed by rains it should be broken up as soon as the condition of the soil will permit. The weeds will be kept in subjection more economically by frequent light tillage than by fewer cultures which will permit them to get a foothold and require more labor in their destruction.

Thinning.—This is the most difficult and expensive operation in beet growing and upon its proper execution the success of the crop largely depends. The distance between the beets in the row should depend upon the quality of the soil, as on a rich, moist soil they will thrive if left much thicker than on a poor dry soil. If planted in extra wide rows to facilitate horse culture, they may be left closer in the rows than otherwise. If the rows are 18–20 inches apart the beets should ordinarily be thinned to 8–10 inches in the rows. The first operation of thinning is done with a common hoe having a blade 5–7 inches wide according to the distance apart it is desired to have the beets stand when the work is complete. When the beets are well started, and usually immediately after the second cultivation, pass along the rows and with the hoe strike out portions the width of the hoe blade, leaving bunches of two or three inches containing several plants. This operation is called bunching and results in the removal of the weeds in the row and the stirring of the soil as well as the removal of most of the surplus plants. Shortly after the bunching the plants remaining are reduced to one in a place and all weeds removed by hand pulling. As this work is usually done by cheap help it is necessary to watch very closely to see that it is well done. One plant, and that the strongest, should be left from each bunch, all the weeds should be *pulled*, not broken off, and if the soil is displaced about the young plant by the removal of the others it must be returned but not packed down hard. The thinning should be done as soon as the plants have four well formed leaves and it is better to employ extra help rather than to delay this work. If the thinning is delayed the beets entwine about one another so that the roots of those left are injured by the removal of the others, and if the tap root is broken the plant will never produce a well formed beet.

Since the soil will become considerably compacted by tramping of the workmen during the thinning it should be immediately loosened by horse cultivation, followed by a thorough hand hoeing. This working should stir the soil three inches deep and leave the crop free from weeds. Under favorable conditions of soil and season the hand-hoeing just after thinning may be the only one necessary for the crop, but if the weeds begin to start close to the rows it will be advisable to hand-hoe once before thinning. Again if rains interfere with the frequent use of the cultivator after thinning and weeds begin to show themselves in the rows another hand-hoeing must be given.

It is impossible to say just how much tillage may be required for best results, but probably one to three hand-hoeings and four to six cultivations will be sufficient.

Some effort was made to determine the effect of very frequent cultivation in comparison with good ordinary tillage. Mr. J. W. Gilmore, a senior in the College of Agriculture, conducted experiments with a series of eight plats, four of which were cultivated seven times and four of them five times with results as shown in the following table.

MR. GILMORE'S CULTURE EXPERIMENTS.

	Tons per acre.	Sugar in juice.	Quotient of Purity.
		Per cent.	
Average of four plats cultivated seven times	19.65	14.26	78.2
Average of four plats cultivated five times	21.68	13.83	75.95

This experiment is given in full on page 516. The averages as given here indicate no gain by seven over five cultivations.

Messrs. D. M. and A. S. Green, Adams, Jefferson County conducted cultural experiments on four plats, two of which were cultivated weekly from June 1st to Sept. 5, and two were cultivated fortnightly for the same period. The results are shown in the following table.

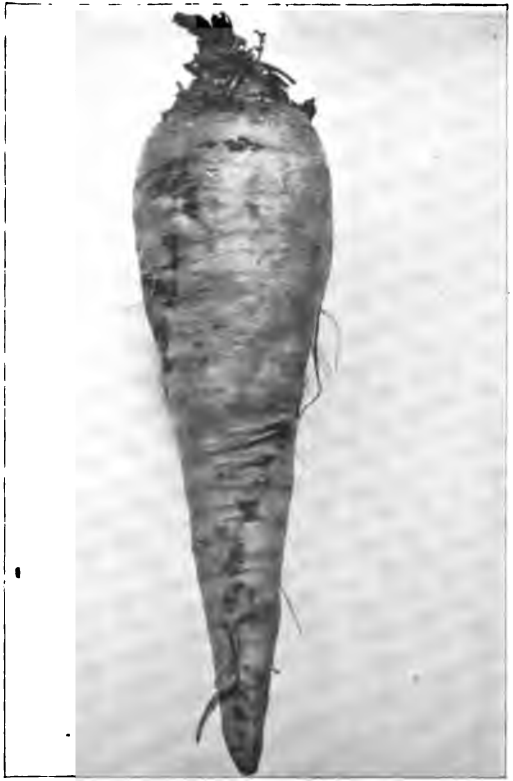
MESSRS. GREEN'S CULTURE EXPERIMENTS.

	Tons per acre.	Sugar in juice.	Quotient of Purity.
		Per cent.	
Average of two plats cultivated weekly	16.00	16.52	84.15
Average of two plats cultivated fortnightly	15.90	16.38	85.39

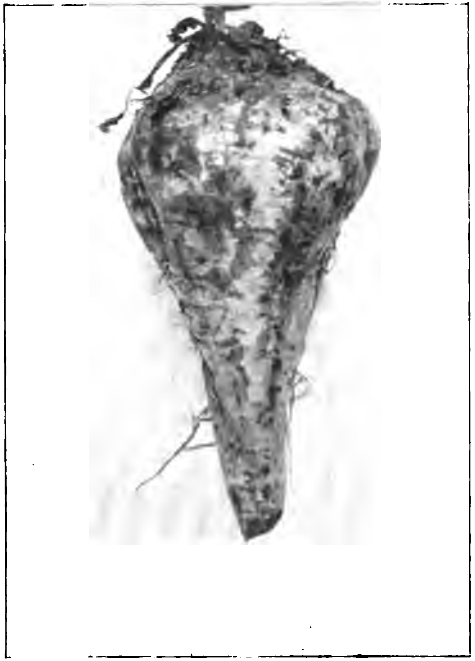
No appreciable gain is seen here as the result of weekly cultivation.

The harvest usually begins the first part of October, though with early planting it may begin a few weeks before, and it should be completed before hard freezing occurs. There are machines for pulling the beets which are said to work very satisfactorily, doing the work as fast as a team will travel. Manufacturers are also making a beet topper with fair prospects of ultimate success, but this has not yet passed the experimental stage.

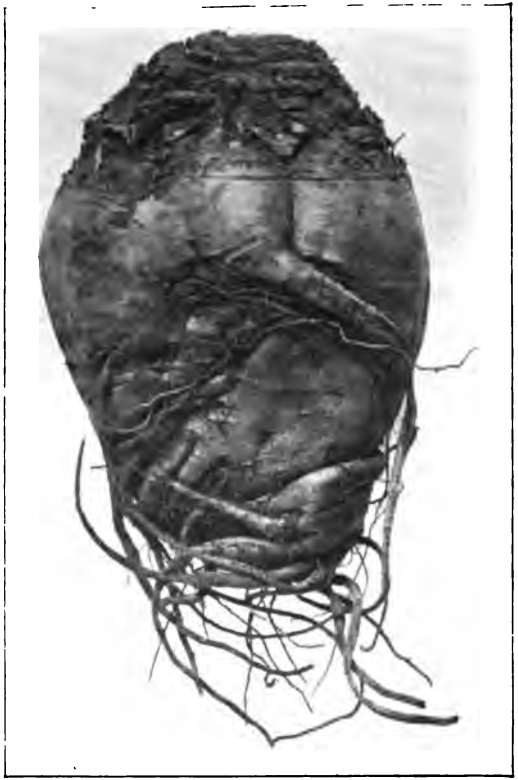
As few farmers are likely to be provided with this special har-



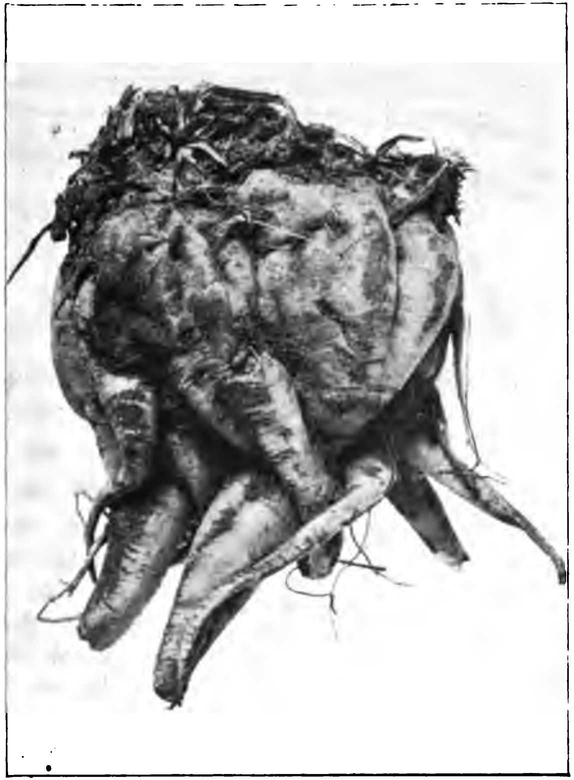
150.—*An Ideal Sugar Beet—grown in good soil with a porous subsoil.*



151.—*A less desirable form of beet. Subsoil so hard or other conditions so unfavorable that the root has grown mostly near or above the surface of the ground.*



152.—*A very large beet grown in rich soil and well tilled, but subsoil too hard and beets allowed too much room.*



153.—“ *Fingers and Toes* ”—*Result of transplanting.*

vesting machinery for several years, a subsoil plow, or a common plow with the mould board removed may be used to loosen the roots. Pull them by hand, throwing into piles and topping with a knife. This knife should be heavy enough so that the crown can be removed at the earth-line by a single well directed blow.

It is important that farmers should understand how to properly trim the beets, for if too much of the crown is left on, carrying with it its large percentage of impurities, the value of the beet for the manufacturer is much reduced. When on a visit to the sugar factory at Rome, N. Y., the past autumn, a dozen men were found at work in the yard removing the crowns from improperly trimmed beets that had been delivered by the farmers. The factory people found it to be better economy to employ men to remove the crowns, rather than to work the beets with the crowns on and suffer the loss of sugar that would not crystallize in consequence. The farmer gains nothing by sending to the factory improperly trimmed beets or those loaded with dirt as the state weigher samples each load, washes,and if necessary trims the sample and determines the percentage of dockage. The farmer not only gets nothing for the crown at the factory but loses its value on the farm as stock food and fertilizer. Fig. 148 on page 492 shows beets properly and improperly trimmed. Where a large portion of the beet grows out of the ground or is ill-formed on account of the soil having been badly prepared the percentage of waste is very much increased. See figs. 148 and 149 p. 498.

If the beets are not needed at the factory as fast as harvested they may be pitted or siloed in the field the same as potatoes, and drawn or shipped to the factory later when the pressure of farm work is not so great. In pitting it is essential that the beets shall be quite mature before harvesting, and that they be secured before freezing occurs, as immature or frosted beets will not keep well.

2. RESULTS OF FERTILIZER EXPERIMENTS WITH SUGAR BEETS AT CORNELL UNIVERSITY EXPERIMENT STATION, 1897.

By L. A. Clinton.

The experiments with sugar beets at this Station in 1897 were for the purpose of determing what effect, if any, different fertilizers would have upon the yield and quality of the beets produced.

In experiments with fertilizers a frequent source of error lies in the fact that the soils of the different plats lack uniformity and hence the fertilizers applied do not have equal opportunity for each to exercise its full effect. To obviate this difficulty the plats upon which the beets were grown were prepared in the following manner. The soil selected was gravelly loam and had been cropped heavily for three years without the application of any fertilizer or manure. In the spring of 1897 a space was measured off for fourteen plats each 4x5 feet in size. The soil of this whole area was then removed to a depth of 24 inches, each layer of eight inches being thrown out upon boards by itself. A solid brick cement wall was constructed around each plat and to a depth of two feet below the surface of the ground. This wall was constructed so that there would be no possible chance for the beets in one plat to receive the benefit of the fertilizer applied to any other plat. After the construction of the wall the soil which had been removed was replaced in the inverse order of its removal, the 8 inches removed last was returned first so that it would occupy its original place at the bottom. Before being returned each eight inches of soil was thoroughly mixed and then an equal number of pounds was put into each plat and packed. In this way all the plats were filled, each layer of soil after having been thoroughly mixed was returned to its original position.

The fertilizers were applied at the time of planting, being put in the bottom of the drill and thoroughly incorporated with the soil before the seed was planted. All the fertilizers were applied in this way except the lime on plat 13 which was applied as a top dressing after the seed was covered.

The fertilizers and the rate per acre applied to each plat were as follows:

Plat 3	Sulfate of potash	554	pounds.
Plat 4	Superphosphate	554	"
Plat 5	Sulfate of potash	277	"
	Nitrate of soda	277	"
Plat 6	Nitrate of soda	554	"
Plat 7	No fertilizer.		
Plat 8	No fertilizer.		
Plat 9	Sulfate of potash	277	"
	Superphosphate	277	"
Plat 10	Nitrate of soda	277	"
	Superphosphate	277	"
Plat 11	Sulfate of potash	184⅔	"
	Nitrate of soda	184⅔	"
	Superphosphate	184⅔	"
Plat 12	Muriate of potash	554	"
Plat 13	Quick lime	1089	"
Plat 14	Ground phosphate rock	1089	"

All plats were planted to beets May 19, the variety being the Kleinwanzlebener. Germination was good and the beets on all plats were finally thinned down to 28 plants to the plat.

Samples were taken for analysis from the various plats October 4, 9 and 20, November 6 and 27. The results of these analyses at the different dates are shown in the following tables:

RESULTS ON PLAT 3—1897.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4	16.70	18.5	90.3
October 9	16.65	18.5	90.0
October 20	17.65	20.6	85.7
November 6	19.30	20.8	92.8
November 27	19.50	21.9	89.0
Average	17.96	20.08	87.56

RESULTS ON PLAT 4—1897.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4..	16.15	18.1	89.2
October 9..	18.70	21.0	89.0
October 20..	18.10	20.8	87.0
November 6..	17.95	19.0	94.5
November 27..	20.00	21.7	92.1
Average.....	18.18	20.12	90.36

RESULTS ON PLAT 5.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4..	15.00	17.2	87.2
October 9	14.55	16.9	86.1
October 20..	18.25	20.8	87.7
November 6..	18.45	19.0	97.1
November 27..	19.15	21.4	89.5
Average.....	17.06	19.66	89.52

RESULTS ON PLAT 6.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4..	17.55	19.7	89 1
October 9..	15.75	18.18	83.7
October 20..	17.35	19.9	87.2
November 6..	18.90	19.4	97.4
November 27..	18.40	20.3	90.6
Average....	17.59	19.496	88.4

RESULTS ON PLAT 7.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity. in juice.
October 4..	16.55	18.5	89.4
October 9..	14.30	17.2	83.1
October 20..	18.25	20.3	89.9
November 6 .	17.70	18.8	94.1
November 27..	19.95	22.3	89.5
Average.	17.35	19.42	89.2

RESULTS ON PLAT 8.

	Per cent sugar in juice	Per cent solids in juice.	Quotient of purity.
October 4..	13.90	16.5	84.2
October 9..	14.80	17.2	86.0
October 20..	18 70	20.6	90.7
November 6..	18.25	19.9	91.7
November 27.	19 80	21.9	90.4
Average.....	17.09	19.22	88.6

RESULTS ON PLAT 9.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4..	15.40	17.9	86.0
October 9..	17.50	19.7	88.8
October 20	17.90	19.2	93.2
November 6..	17.95	18.3	98.1
November 27..	18.70	20.6	90.8
Average.....	17.49	19.14	91.38

RESULTS ON PLAT 10.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4..	15.40	18.5	83.2
October 9..	17.40	19.2	90.6
October 20..	19.75	21.7	91.0
November .6..	18.00	18.8	95.7
November 27..	18.65	21.0	88.8
Average.....	17.84	19.84	89 86

RESULTS ON PLAT 11.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4..	16.95	19.4	87.4
October 9..	17.30	19.2	90.1
October 20..	20.00	21.2	94.3
November 6..	18.00	19.2	93 7
November 27..	19.40	21.4	90.6
Average.....	18.35	20.08	91.22

RESULTS ON PLAT 12.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4..	17.00	19.4	87.6
October 9..	16.70	18.8	88.8
October 20..	21.10	22.5	93.8
November 6..	18.05	20.6	87.6
November 27..	20.50	22.3	91.9
Average.....	18.67	20.72	89.94

RESULTS ON PLAT 13.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4	14.90	17.6	84.6
October 9..	15.50	19.0	80.2
October 20..	19.00	19.7	96.4
November 6..	18.15	20.1	90.3
November 27..	19.25	20.1	95.7
Average.....	17.36	19.3	89.44

RESULTS NO PLAT 14.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4..	14.25	16.5	86.4
October 9..	16.05	18.3	87.7
October 20..	17.95	19.7	91.1
November 6..	17.55	20.1	87.3
November 27..	19.40	20.8	93.2
Average.....	17.04	19.08	89.14

ALL PLATS.

AVERAGE RESULTS AT DIFFERENT DATES.

	Per cent sugar in juice.	Per cent solids in juice.	Quotient of purity.
October 4..	15.81	18.15	87.05
October 9 .	16.26	18.60	87.00
October 20..	18.66	20.6	90.7
November 6..	18.18	19.5	93.36
November 20..	19.40	21.56	91.00

COMBINED RESULTS OF ALL PLATS.

Plat	Fertilizer rate per acre.	Pounds of beets with crowns.	Per cent sugar in juice.	Per cent solids.	Quotient of purity.
3	554 pounds Sulfate Potash.....	19.2	17.96	20.08	87.56
4	554 pounds Superphosphate...	18.3	18.18	20.12	90.36
5	277 pounds Sulfate Potash..... 277 pounds Nitrate Soda........	21.6	17.06	19.06	89.5
6	554 pounds Nitrate Soda.......	19.9	17.59	19.49	88.4
7	No Fertilizer.................	17.3	17.35	19.42	89.2
8	No Fertilizer................	19.7	17.09	19.22	88.6
9	277 pounds Sulfate Potash..... 277 pounds Superphosphate....	18.6	17.49	19.14	91.38
10	277 pounds Nitrate Soda....... 277 pounds Superphosphate....	21.1	17.84	19.84	89.86
11	184⅔ pounds Sulfate Potash.. 184⅔ pounds Nitrate Soda... 184⅔ pounds Superphosphate..	18.3	18.35	20.08	91.22
12	554 pounds Muriate Potash....	19.7	18.67	20.72	89.94
13	1089 pounds Quick Lime......	19.5	17.36	19.3	89.44
14	1089 pounds Ground Phosphate Rock......................	21.9	17.04	19.08	89.14

While the yield was somewhat low, yet this can be accounted for by the fact that the subsoil had been so thoroughly loosened somewhat late in the spring that capillary action was not fully restored and hence the beets failed to make as large a growth as would have been the case had the conditions been more favorable.

The effect of the fertilizer is not marked. The largest yield was on Plat 14 where the untreated phosphate rock was applied. The highest quotient of purity was found on Plat 11 where the complete fertilizer was applied. The results from the fertilizer are not marked enough to warrant the drawing of conclusions. There was evidently all the plant food in the soil that could be utilized with the amount of moisture present. The experiment will be continued to see if more definite results can be reached.

Mr. J. W. Gilmore, conducted culture and fertilizer experiments with sugar beets on eight plats of one-eightieth of an acre each. The land selected upon which to conduct these experiments was a portion of the regular mangold field which had been liberally fertilized with barn manures in previous years and brought to a high state of cultivation. The variety of beets was Kleinwanzlebener, planted in rows two feet apart and thinned to about eight inches in the row. The fertilizer was applied in the drill at the time of planting. Part of the plats received cultivation five times and others were cultivated seven times. The following table shows results.

Plat.	No. times cultivated.	Fertilizer applied per acre. Pounds.	Tons per acre with crown.	Tons per acre without crown.	Per cent sugar. in juice	Quotient of purity.
1	7	160 lbs. Muriate Potash.........	19.63	14.86	14.48	79.04
2	5	320 lbs. Superphosphate	21.70	16.38	14.63	76.85
3	7	160 lbs. Nitrate Soda...........	19.02	14.36	14.80	80.00
4	5	320 lbs. Superphosphate	19.95	15.06	14.14	76.00
5	7	160 lbs. Sulfate Potash	21.82	16.48	13.40	76.19
6	5	320 lbs. Superphosphate	23.31	17.60	13.67	76.76
7	7	160 lbs. Nitrate Soda...........	18.12	13.68	14.34	77.60
8	5	160 lbs. Sulfate Potash..........	21.74	16.41	12.88	74.20

The results shown here from the use of the commercial fertilizer are not much more decided than in the former case. While the tonnage per acre is very satisfactory, yet the per cent of sugar and the quotient of purity run somewhat low. This is probably due to the fact that barn manures have been used liberally on the land, and to the same cause may be ascribed the failure of the fertilizers to give any marked results. It is generally stated that sugar beets are especially benefited by the application of potash and phosphoric acid, and that the form of the sulfate of potash is preferable. So far as our experiments with fertilizers this year go we have not verified the truth of this statement.

PART II.

THE WORK OF THE CHEMICAL DIVISION.

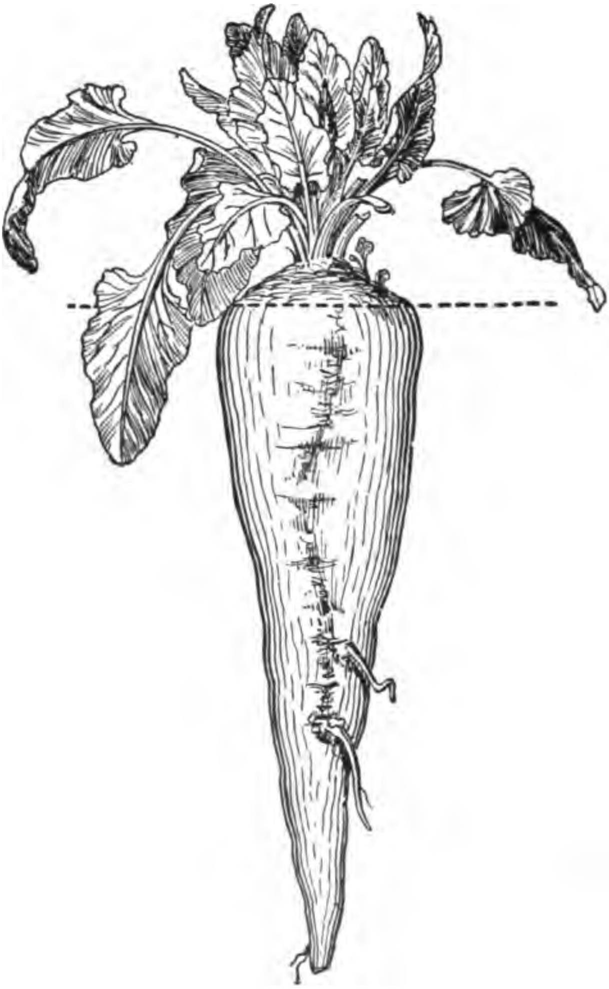
By G. W. Cavanaugh and A. L. Knisely, assisted by C. W. Mudge, under the direction of G. C. Caldwell, Chemist.

In order that the work of the chemical department, in connection with the sugar beet investigations, might be of real and permanent value, it was necessary to secure not only representative samples of the beets grown, but also accurate and carefully recorded data relative to their culture. With this end in view the coöperation of intelligent farmers who have already given evidence of an active interest in educational and experimental work was sought. The instructions in grape growing and orcharding which had been carried on for two previous years had eminently fitted a goodly number of farmers to take up the work of sugar beet culture in an intelligent way.

The circular on page 517 which was sent out at the close of the season was filled out with far more painstaking care than is usual in such cases. These reports give unmistakable evidence that the work already done by the Station staff had been of great value. In fact it had trained a large number of farmers far enough to make them intelligent observers and willing to take some pains to record their observations. Much care has been taken to put down all the data in detail and while these tables may be of little interest to the general reader, it is hoped that the data recorded will be of value for reference as the work goes on.

We desire to thank all those who have coöperated with so much care in the field work. The work in the laboratory, which has been very extended, would be of comparatively little value if we did not feel that the notes and observations of the farmers were reliable.

CIRCULAR NO. 11.



154, WILEY, Bulletin 52, Division of Chemistry, United States Department of Agriculture.

CORNELL UNIVERSITY,
AGRICULTURAL EXPERIMENT STATION,

Ithaca, N. Y., September 15, 1897.

SIR:

We inclose herewith circular giving directions for taking samples of beets for analysis, blank for describing samples (Form A), and MODEL (Form B), showing how blank for description should be filled in, with envelope and return shipping tag for sending samples by express.

Circular of directions, blank for describing samples with envelope, return-addressed shipping tag, and model for filling in descriptive blank, comprise the necessary documents for sending samples.

Your special attention is called to the fact that the value of the analytical data depends on the fidelity with which you follow the inclosed directions.

I. P. ROBERTS, Director.

DIRECTIONS FOR TAKING SAMPLES OF SUGAR BEETS FOR ANALYSIS.

When the beets appear to be mature (September 20 to November 20, according to latitude and time of planting) and before any second growth takes place, select an average row or rows, and gather every plant along a distance which should vary as follows, according to the width between rows:

From	rows	16	inches	apart	take	75	feet	in	length.
"	"	18	"	"	"	66	"	"	"
"	"	20	"	"	"	59	"	"	"
"	"	22	"	"	"	54·8	"	"	"
"	"	24	"	"	"	50	"	"	"
"	"	28	"	"	"	42.9	"	"	"
"	"	32	"	"	"	37·5	"	"	"
"	"	36	"	"	"	33	"	"	"

Where the row is not long enough to meet the above conditions take enough from the adjacent row or rows to make up the required length. Rows of average excellence must be selected; avoid the best or poorest. Count all the beets in the length of the row taken. Remove the tops leaving about one inch of the stem, wash free from all dirt and wipe dry. Select two average beets, being careful not to select the largest or the smallest.

From all the rest of the beets *except these two* the necks are removed with a sharp knife, at the point indicated by the dotted line in the figure. The beets, including the two saved as a sample, are then weighed.

The number of beets harvested multiplied by 435.6 will give the total number per acre. The total weight of beets harvested multiplied by 435.6 will give the yield per acre.

Wrap the two sample beets carefully in soft paper and write your name legibly thereon. The beets must be perfectly dry. Fill out blank describing beets, place in the envelope, and enclose beets. Sew the beets up in a cotton bag or wrap in strong paper, attach the enclosed shipping tag thereto and send by U. S. mail.

No beets will be analyzed which are not sampled as described above and properly identified. Miscellaneous analyses of samples without accurate description are of no value.

A model showing how blanks should be filled out is inclosed.

Model (Form B).

MODEL FOR DESCRIBING SAMPLE OF SUGAR BEETS.

Variety.................................*Klein Wanzlebener.*

Date planted.................................*May 3, 1897.*

Date thinned.................................*June 3, 1897.*

Date harvested.............................*November 5, 1897.*

Character of soil..............*loam; in cultivation for 20 years, chiefly in corn; level, tile-drained; last crop, oats; no fertilizer was used; barn-yard manure applied in 1895.*

Character of cultivation (dates, implements, etc.).....*plowed November, 1896, eight inches deep, subsoiled, six inches; harrowed with disk harrow May 1, 1897; rolled; seed planted with hand drill one-half inch deep; plants up May 16; stand excellent; hoed by hand May 22; plowed with horse hoe May 28 and June 8, 16, 24, July 3, 10, and 17.*

Length of row harvested (feet).............................66

Width between rows (inches).............................18

Number of beets harvested.............................88

Total weight of beets, less necks and tops (pounds)..........88

....

Weather for each month....*May, dry; June, copious rains; July, fine growing weather; August, hot and dry; September, dry until the 24th, when a heavy rain fell.*

....

....

State.................................*New York.*

Post office.............................*Ithaca, Tompkins Co.*

Date.................................*October 1, 1897.*

Name.................................*Robert Simpson.*

NOTE.—Beets will not be analyzed unless accompanied with description as above.

(Form A.)

DESCRIPTION OF SAMPLE OF SUGAR BEETS.

Variety .... *Klein Wanzlebener.*

Date planted .... *May 7, 1897*

Date thinned .... *June 10, 1897.*

Date harvested .... *October 18, 1897.*

Character of soil .... *clay loam; in cultivation 65 years. Used 30 years for garden level. Tile drained. Barn manure in '92. Hen manure used occasionally. Last in fall '96.*

Character of cultivation (dates, implements, etc.).... *plowed May 1st, 9 inches deep; harrowed 3 times. Seed sown by hand. Up May 16, stand excellent; horse cultivated 3 times; hand hoed twice.*

....

Length of row harvested (feet) 42.9

Width between rows (inches) 28

Number of beets harvested 60

Total weight of beets harvested, less necks and tops (pounds). 95

Weather for each month ....

....

....

....

State .... *N. Y.*

Post-office .... *Riga.*

Date .... *October 18, 1897.*

Name .... *Arnold A. Palmer.*

NOTE.—Samples of beets will not be analyzed unless accompanied with this blank filled out as indicated in model B.

G. C. CALDWELL, Chemist.
G. W. CAVANAUGH, Ass't Chemist.

The first question that arises is this: In what condition did the samples for analysis arrive at the Experiment Station? With but few exceptions they arrived in very good condition, well wrapped and securely tied. The majority of them were received in from one to three days after being harvested and in good condition for analysis.

The fairness of the samples.—Were the beets sent to the Station for analysis of good average size and did they fairly represent the beets harvested? In the data sent in the circulars, we have the *number of beets harvested* and also *the total weight* of beets harvested, less necks and tops, in pounds. From these we obtain the average size, or weight of each crownless beet harvested.

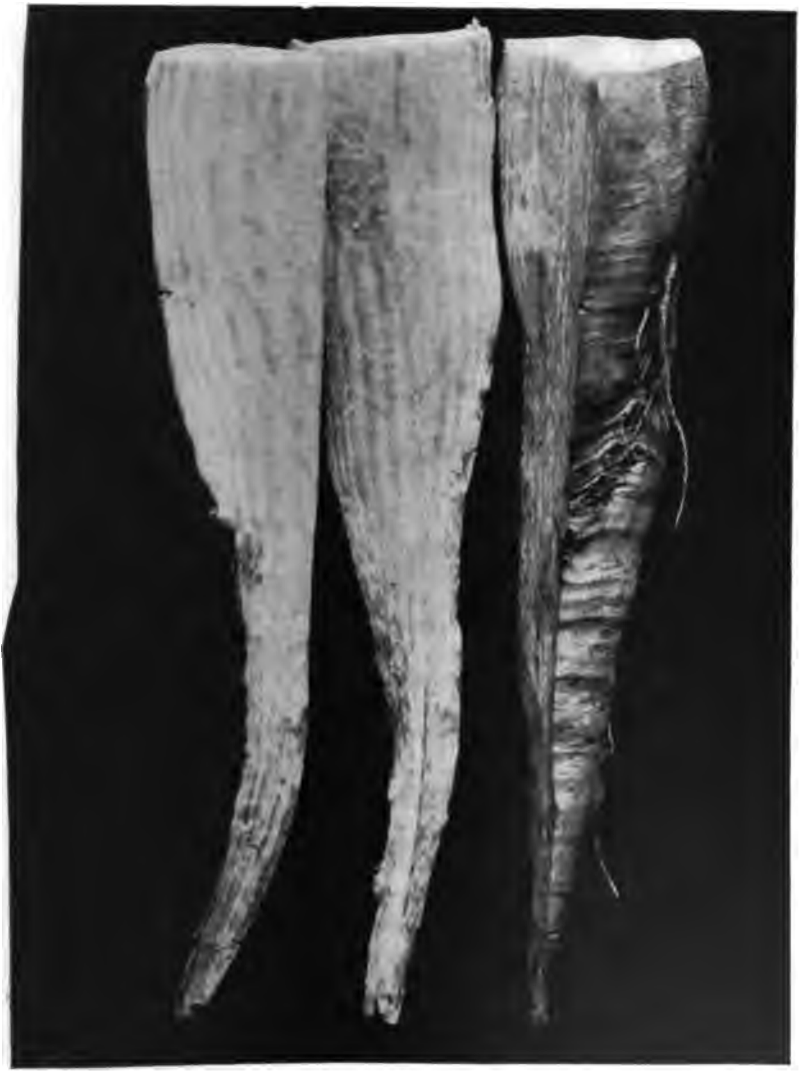
The whole sample received was weighed after removing crowns and the average weight of each beet obtained. Now by comparing the *average weight harvested* with the *average weight of beets in the sample analyzed*, we can see with what degree of accuracy the samples were taken.

In 296 cases the average weight of the individual beets harvested was *1.18 pounds each.* In these same 296 cases the average weight of the beets sent for analysis averaged *1.18 pounds each.* So it will be seen, that on the whole the sampling of beets was very well done.

Preparation of the sample for analysis.—Each sample was weighed *before* and *after* removing the crown in order to ascertain the loss or waste that the beet sustains while being prepared for the sugar factory.

The sample thus prepared was reduced to a fine pulp by means of a grater. If the sample was small all of it was pulped for analysis; if of medium size half of each beet was analyzed; in some cases only a quarter of each beet was taken. In all cases where the whole beet was not used, a longitudinal section the entire length of it was taken for analysis as shown in Fig. 155 (next page). The pulp was at once put into a piece of strong canvass and the juice pressed out by means of a press capable of exerting a pressure of 2,000 pounds or more.

The necessity of taking a longitudinal section the entire length



155.—*Methods of sampling large beets for analysis.*

of the beet would seem to be proved by the results of the following five experiments.

Five samples consisting of three beets each (*without crowns*) were cut in two, crosswise, so that the upper and lower halves of each sample could be examined separately. These halves were analyzed with the following results:

Case.	Upper half.		Lower half.	
	Per cent sugar.	Per cent purity.	Per cent sugar.	Per cent purity.
1	13.95	77.1	13.60	79.1
2	14.45	83.0	14.20	87.1
3	13.25	78.4	13.00	81.2
4	13.05	77.2	12.95	81.9
5	17.25	89.8	17.00	89.5

In these five cases the sugar and purity were not equally distributed. The upper halves being richer in sugar whilst the purity was considerably higher in the lower halves except in No. 5.

In obtaining juice for analysis it is necessary to express as much as possible from the pulp, because that which *first runs from the press* is not so rich in sugar as that which is obtained toward the *end* of the operation. Thus in five cases tried the per cent of sugar and per cent of purity were as follows:

Juice first running from press.			Juice last running from press.	
	Per cent sugar.	Per cent purity	Per cent sugar.	Per cent purity.
Case 1	13.55	82.1	14.00	82.8
" 2	15.20	76.4	15.75	76.5
" 3	18.45	87.9	18.45	87.9
" 4	12.85	71.8	13.95	74.2
" 5	19.35	89.1	19.50	96.0

Method of Analysis.

When all the juice was pressed out that could be obtained, it was thoroughly mixed and its *density* ascertained by means of an areometer (Brix) specially constructed for this purpose and from that the total solids of the juice found; corrections were made for variations in temperature where necessary.

Next, 52.096 grams of the juice were weighed and transferred to a 100 c.c. flask; 10 c.c. of a solution of sub-acetate of lead, made as directed in Wiley Agr. Anal. III, p. 101, were added; after shaking the mixture it was made up to 100 c.c. with distilled water and again thoroughly shaken. Then the entire contents of the flask were poured on a ribbed filter, the first part of filtrate being poured a second time through the same filter; the filtrate was thoroughly mixed and the sugar in it determined by means of a "double compensating shadow polariscope" now in general use for this purpose, using a 200 mm. tube. This reading divided by two gives the per cent of *sugar in the juice.*

Explanation of Tables.

In the following tables we have given in the first three columns: 1st, degree Brix or per cent of total solids in the juice; 2d, per cent of sugar in the juice; and 3d, per cent of purity of the juice. We will consider:

FIRST. THE DEGREE BRIX OR PER CENT TOTAL SOLIDS IN THE JUICE.—Beet juice consists of water and solid matter consisting of sugar, mineral salts, coloring matter, nitrogenous compounds, etc. The first beet juice in the tables reads "19.9° Brix." This means that 19.9 per cent of that juice is solid matter and the remaining 80.1 per cent is water; or in other words, in 100 pounds of such a juice there are 19.9 pounds solid matter and 80.1 pounds of water.

SECOND. THE PER CENT OF SUGAR IN THE JUICE.—This per cent is determined by the polariscope. The first beet juice in the tables analyzed 17.25 per cent of sugar. This means that in 100 pounds of that juice there are 17.25 pounds of sugar.

THIRD. PURITY PER CENT.—This term is often called the coefficient of purity, or better still the quotient of purity. It expresses the ratio between the *per cent of total solids in the juice* and the *per cent of sugar in that same juice.* That is, in any particular juice, the *purity* expresses what proportion of the total solids is sugar. Thus in the juice first analyzed, in the following tables there is given, "*Purity per cent, 86.6.*" This means that if such a juice were evaporated to dryness and the total solid matter obtained, then of the solids thus obtained 86.6 per cent would be sugar and the remaining 13.4 per cent would be impurities not sugar; or stated in another way, in every 100 lbs. of the solid matter obtained by evaporating the juice, 86.6 lbs. would be sugar and the remaining 13.4 lbs. would be impurities and not sugar.

In any given case the *purity* is obtained by dividing the *per cent of sugar* in the juice times 100 by the *per cent of total solids* in that same juice. Thus in sample No. 1 of the following tables $\frac{17.25\times 100}{19.9}=86.6$ per cent purity. The term *purity* is not an indication of the quality of a *juice*, but of the quality of the *total solids* in the juice; that is, it tells *how many parts are sugar in every 100 parts of the total solids.*

Per cent of sugar in beets without crowns.—It has been stated upon good authority (Wiley, Agr. Anal. III, p. 242) that 95 per cent of the beet consists of *juice* and 5 per cent *marc*, or that which is left after all the juice has been extracted. That is, each 100 pounds of beets prepared for the factory yields 95 pounds of juice and 5 pounds of marc. Having given the per cent of sugar in each sample of *juice*, we multiply it by $\frac{95}{100}$ and have the per cent of sugar in the *beet.* The column headed *per cent sugar in the beet* was obtained in each case by this multiplication and the result was recorded as per cent of sugar in the beet.

Thus in first analysis of tables $17.25\times\frac{95}{100}=16.39$, the per cent sugar in the beet.

Pounds of sugar per ton of beets.—In each case we multiply the per cent of sugar in the beet, or the number of pounds in 100 pounds of beets by 20, a ton being 20 times 100 pounds, and record the result as pounds of sugar per ton of beets, discarding decimals. Thus in first analysis $16.39\times 20=328$ pounds, approximately, of sugar per ton.

Pounds of sugar per acre.—In cases where yields have been given, we multiply the pounds of sugar per ton by the number of tons yield per acre. Thus 7.84×328 pounds$=2572$ pounds per acre (discarding decimals).

Kind of soil.—L = loam.

When plowed and depth, inches.—In this column, F = fall plowed; S = spring plowed. The numeral indicates depth in inches.

The remainder of the tables is self explanatory with the exception of "*Distance between beets in rows*" and "*Average weight of beets.*" From data sent to the Station, the *length of the rows* and the whole *number of beets* harvested were given and from these the average distance between each beet in the rows was calculated. From the recorded total weight and number of the beets harvested the average weight of the beets *less crowns and tops* was ascertained.

Each sample of beets sent for analysis was weighed and thus the average weight of beets analyzed was found.

The variety of beets analyzed.—In each case the variety of Sugar Beet analyzed was the *Kleinwanzlebener*, except toward the end of the tables where special mention is made of other varieties.

We believe that these tables will be of enough value and interest to warrant their publication. They are not published with the thought or idea of having established either a *maximum* or *minimum* of results in the growing of sugar beets, but are given as showing *what the farmers have done this present season* (summer of 1897).

Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			Pounds of sugar per acre.
					Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	
	Albany.							
1 W. D. Veeder...	Guilderl'd	19.9	17.25	86.6	16.39	328	7.84	2572
	Broome.							
2 A. S. Bartlett...	Bingh'ton	20.6	17.85	86.6	16.96	339	*19.69	6675
3 David Smith ...	"	19.5	16.20	83.1	15.39	308	*18.91	5824
4 E. A. Lawrence.	"	21.2	18.10	85.4	17.19	344	*21.88	7527
5 A. R. Park......	"	21.9	18.65	85.2	17.72	354	*16.90	5983
6 Geo. A. Lusk...	"	22.2	19.00	85.6	18.05	361	8.49	3065
7 W. S. Stone.....	"	20.6	17.10	83.0	16.25	325	*16.03	5210
8 J. E. Rogers....	"	21.5	18.20	84.7	17.29	346	*14.98	5183
9 G. E. Larraber..	"	17.0	12.45	73.2	11.83	237	*13.80	3271
10 C. Rogers.......	"	21.5	18.00	83.7	17.10	342	*34.33	11741
11 W. S. Weed.....	"	20.4	16.65	81.6	15.82	316	*13.28	4196
12 C. E. Lee.......	"	20.6	17.00	82.5	16.15	323	*25.78	8327
13 R. W. Wright..	"	19.1	15.50	81.2	14.73	295	*14.29	4216
14 Geo. F. Lyon...	"	17.0	13.10	77.1	12.45	249	*14.29	3558
15 David Smith, Jr.	"	20.2	16.50	81.7	15.68	314	*19.51	6126
16 A. Hamilton....	"	19,3	15.55	80.6	14.77	295	*20.74	6118
17 H. S. Martin....	"	22.8	19.25	84.4	18.29	366	*23.18	8484
18 C. Constable....	"	18.1	14.50	80.1	13.78	275	*20.21	5578
19 J. M. Price.....	"	17.2	13.45	78.2	12.78	256	*13.94	3569
20 E. C. Rogers....	"	19.0	14.15	74.4	13.44	269	*19.86	5342
21 C. J. Knapp.....	"	20.8	16.50	79.3	15.68	314	*24.00	7536
22 C. P. Knapp....	Deposit..	16.3	12.00	73 6	11.40	228	*22.88	5217
23 C. H. Wells.....	Pt.Dickson.	19.7	17.15	87.0	16.29	326	*17.07	5565
24 Alton Gray. ...	Hooper...	19.3	14.20	73.6	13.49	270	*24.74	6680
25 Abram Davis....	Langdon.	21.2	17.85	84.2	16.96	339	*12.76	4326
26 R. W. Evans....	Riverside.	20.1	16.40	81.5	15.58	312	*16.98	5298
27 J. E. Croffutt...	W. Colesv.	20.3	17.00	83.7	16.15	323	*23.00	7429
28 D. E. Pease.....	Windsor.	20.6	16.80	81.5	15.96	319	*25.09	8004
29 H. W. Humiston	"	19.2	15.45	80.5	14.68	294	*27.18	7991

* Through the courtesy of Mr. J. E. Rogers, of Binghamton, the Station has received most of the Broome County samples of beets. The yields reported in cases "starred" included crowns; therefore in each of the cases the yield has been reduced one-fifth to allow for the weight lost in removing crowns.

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation, Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows...	Between beets in rows.......	Harvested......	In samples analyzed....
Sandy.	40	Carrots		F.&S. 8	3	Jun. 18	Jul. 27	Oct. 30	36	14.5	1.00	1.00
Clay. L.				S.	4	M'y 22	Jun. 18	Oct. 23	20	9.0	1.42	.96
" "				"		" 18	" 16	" 22	18	9.0	1.27	1.24
Sandy "				"	3	Jun. 2	" 30	" 21	18	9.0	1.36	.89
" "			'96	"	5	M'y 10	" 15	" 20	20	9.0	1.21	.73
Gravel "					3	" 26	" 23	" 20	36	9.0	.87	1.51
Sandy "					3	" 19	" 23	" 20	18	9.0	1.15	1.34
" "					4	" 19	" 16	" 18	18	9.5	1.05	1.45
Clay "					5	" 7	" 4	" 17				1.50
Sandy "					3	" 15	" 20	" 19	24	6.0	1.91	1.63
Sod					5	" 25	" 26	" 18	36	6.0		1.49
Clay "					3	" 22	" 6	" 19	18	10.0	1.87	1.60
Sandy "					3	" 28	" 22	" 20	36	8.5	1.78	1.73
Gravel "					4	" 12	" 26	" 19	36	9.5	2.00	1.60
Clay "					4	" 16	" 22	" 29	18	11.0	1.56	1.70
Sandy "					5	Jun. 2	" 23	" 23	20	9.0	1.29	1.46
Black "		Garden			3	" 3	Jul. 2	" 29	12	9.5	1.58	1.70
Clay "					4	M'y 28	Jun. 15	" 28	18	9.0	1.33	1.54
Sandy "			'96	F. & S.	5	" 13	" 24	Nov. 8	36	7.0	1.48	1.27
Loam		Garden	'97	S., 8.		" 20	Jul. 15	Oct. 21	24	8.5	1.61	1.68
"						Jun. 2	Jun. 29	" 28				.86
Sandy "						M'y 20	" 16	" 15	18	10.0	1.95	1.73
Clay "						" 18	" 20	" 19	36	7.0	1.69	1.19
" "			'96	S.		" 11	" 20	" 29	24	8.5	2.03	1.07
" "					4	Jun. 2	" 26	Nov. 3	36	8.5	.77	1.05
Sandy "					4	M'y 25	" 17	" 3	20	12.5	1.54	1.58
Clay "					3	Jun. 28	Jul. 16	" 2	18	8.5	1.45	1.30
Sandy "					2	" 17	" 10	Oct. 18	18	8.0	1.50	.88
" "					3	" 2	" 1	Sep 18	18	8.0	1.39	.71

Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			
					Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
	Catta'gus.							
30 W. B. Smith....	Cottage..	20.6	18.55	90.0	17.62	352	28.75	10120
31 L. L. Palmer....	S. Dayton	21.5	18.40	85.6	17.48	350	13.06	4571
32 D. Achley	Gowanda .	21.1	18.55	87.9	17.62	352	13.83	4868
33 Clay Torrence...	"	19.9	17.10	85.9	16.25	325	......	......
34 "	"	19.4	16.20	83.5	15.39	308	......	......
35 "	"	19.9	16.85	84.6	16.01	320	......	......
36 "	"	20.2	17.60	87.1	16.72	334	......	......
37 Jerome Kennedy	Versailles.	19.2	15.30	79.7	14.54	291	......	......
38 Peter Pierce....	"	14.7	10.85	73.8	10.31	206	......	......
39 Eli Pierce	"	17.4	12.90	74.1	12.26	245	......	......
40 H. H. Thomas..	Farmerv..	19.7	16.65	84.5	15.82	316	......	......
41 John Hall ...	W.P'rrysb	23.9	21.50	90.0	20.43	409	9.80	4008
42 Clayton Gates...	Conew'go V	20.6	17.60	85.4	16.72	334	15.46	5164
43 E. F. Davis.....	Hinsdale .	21.0	18.40	87.6	17.48	350	......	......
44 "	"	20.1	17.65	87.8	16.77	335	......	......
	Cayuga.							
45 Sam. Searing ...	Poplar R .	20.1	18.10	90.0	17.20	344	14.16	4871
46 I. P. Hazard....	"	19.5	15.25	78.2	14.49	290	11.43	3315
47 Thomas Mitchell	"	19.5	15.95	81.8	15.15	303	14.37	4354
48 E. Cook........	"	21.7	18.95	87.3	18.00	360	14.37	5173
49 Nathan Bacon...	Westbury.	21.0	18.65	88.8	17.72	354	15.86	5614
50 J. N. Shotwell..	"	20.8	17.15	82.4	16.29	326	18.86	6148
51 Dan. Olmstead..	"	19.7	16.40	83.2	15.58	312	......	......
52 W. F. Searing...	Sherwood.	22.5	19.80	88.0	18.81	376	6.21	2335
53 D. Duryea......	Auburn..	19.9	16.10	80.9	15.30	306	......	......
54 J. Brinkerhoff..	"	19.0	14 85	78.2	14.11	282	......	......
55 H. A. Lamphere	Weedspo't	20.6	17.05	82.7	16.20	324	47.75	15471

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations..	Planting.	Thinning.	Harvesting.	Between rows...	Between beets in rows........	Harvested.....	In samples analyzed......
Gravel L					4	M'y 26		Oct. 23	32	7.5	2.20	1.43
Clay “				S., 7	3	“ 25	Jun. 25	“ 16	28	10.0	1.20	1.46
Sandy “	70	Corn	'95	“ 5		Jun. 8	“ 24	“ 18	24	6.5	.7	1.56
Bottom L'd.												1.61
“ “												2.16
“ “												1.95
“ “												2.03
“ “						M'y 20	“ 20	“ 20				.79
Clay L						“ 26	“ 20	“ 20				1.43
						Jun. 21	Jul. 10	“ 20				1.46
												1.19
Black “		Oats		S.,		M'y 25	Jun. 24	“ 26	36	9.0	1.07	1.74
Gravel “		Hay		“ 6	7	“ 30	“ 29	Nov. 3	24	8.5	1.00	1.17
Loam	20	Cabbage		“ 8		“ 10		“ 18	20			1.39
												1.00
Sandy L		Oats	'96	S., 8	4	“ 18	Jul. 2	“ 6	42	7.0	1.30	1.40
Loam.					1	“ 15	“ 6	Oct. 21	30	8.0	1.17	1.17
Clay L		Oats	'97	“ 7	3	“ 20	“ 2	“ 19	32	9.5	1.37	1.20
Loam.			'97		7	“ 25	“ 15	“ 25	36	9.0	1.50	1.49
Clay L	75	Sod		“ 6	5	“ 20	“ 25	“ 13	36	6.5	1.22	.91
Sandy “	75		'96	“	3	“ 12	Aug	“ 13	15	6.0	.56	.55
“ “	50		'97	“ 6	6	“ 12	“ 20	“ 12	14	6.0	1.59	1.42
Loam	100		'97	“ 8	9	“ 15	Jul. 6	Nov. 6	35	12.0	.85	.92
												.61
Gravel L						Jun. 1		“ 15	24			1.42
Sandy “	50		'97	“ 8	3	M'y 15	Jun. 10	“ 15	22	6.0	2.00	1.65

Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			
					Per ct. sugar in the beet	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
	Chau'qua.							
56 L. Newton	Irving	19.7	17.60	89.3	16.72	334	30.92	10327
57 R. L. Newton	“	19.2	16.50	85.9	15.68	314	26.00	8164
58 Frank Newton	“	17.5	13.40	76.6	12.73	255	31.36	7997
59 James Duffy	“	19.7	16.15	82.0	15.34	307	......	......
60 “	“	19.7	16.30	82.7	15.49	310	33.32	10329
61 “	“	17.4	14.20	81.6	13.49	270	......	......
62 D. Burmaster	“	21.2	18.00	84.9	17.10	342	......	......
63 A. D. Burmaster	“	20.6	17.25	83.7	16.39	328	......	......
64 “	“	20.8	16.80	80.8	15.96	319	......	......
65 “	“	19.7	16.50	83.8	15.68	314	31.36	9847
66 C. A. Burmaster	“	19.7	16.40	83.2	15.58	312	31.80	9922
67 “	“	19.2	16.40	85.4	15.58	312	31.80	9922
68 Wm. Hull	“	18.5	15.55	84.0	14.77	295	26.00	7670
69 “	“	16.0	12.15	75.9	11.54	231	......	......
70 “	“	17.9	14.45	80.7	13.73	275	28.75	7906
71 H. E. Goodell	“	23.2	20.40	88.5	19.38	388	......	......
72 L. Newton	“	21.0	18.25	86.9	17.34	347	.....	......
73 R. L. Newton	“	22.1	19.00	86.0	18.05	361	......	.....
74 Israel Mott	“	18.8	14.50	77.1	13.78	275	......	......
75 Jas. J. Mott	“	18.5	14.70	79.5	13.97	279	29.18	8141
76 “	“	21.5	15.50	72.1	14.73	295	......	......
77 D. G. Smith	“	17.7	15.00	84.7	14.25	285	18.00	5130
78 W. B. Horton	“	18.1	14.60	80.7	13.87	277	21.00	5817
79 H. M. Goodell	“	20.8	17.45	83.9	16.58	332	......	......
80 “	“	22.5	18.65	82.9	17.72	354	......	......
81 “	“	18.3	13.50	73.8	12.83	256	......	......
82 I. J. Mott	“	17.0	12.50	73.5	11.88	238	9.76	2323
83 R. L. Newton	“	20.2	17.20	85.1	16.34	327	17.36	5677
84 Jas. Duffy	“	18.6	14.65	78.8	13.92	278	33.35	9271
85 B. Barker	“	18.3	13.90	76.0	13.21	264	......	......
86 G. S. Stevins	“	20.2	17.35	85.9	16.48	330	29.29	9666

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows	Between beets in rows	Harvested	In samples analyzed
Bottom L'd	30			S.	4	Jun. 14	Jul. 14	Oct. 13	18	9.0	1.61	1.23
"	20					" 14	" 1	" 13				1.32
"				" 8	4	M'y 27	Jun. 10	" 6	18	9.5	1.75	.97
"						" 14	" 10	" 20				1.37
"	35		'95	"	4	Jun. 12	Jul. 1	" 20	16	10.0	1.68	1.46
Loam						M'y 28	" 25	Nov 27	16			2.67
						" 24	Jun. 16	Oct. 20				1.44
												1.29
												.50
Bottom L'd	30			S&F 10	3	" 27	" 15	" 6	18	8.0	1.41	1.05
"	30				4	Jun. 3	" 26	" 13	18	9.0	1.62	.85
"					4	" 3	" 26	" 13	18	9.0	1.62	.74
"	20			S.	4	M'y 26	" 10	" 13				1.20
"				"		" 26	" 10	" 13				.78
"	15			" 8	5	" 25	" 4	" 6	18	9.0	1.50	.94
						Jun. 20		Nov 20	16			.66
						" 14	" 30	Oct. 20				1.15
"	20					" 14	Jul. 1	" 13				.80
Alluv'l L.						" 10	" 1	" 20				.75
"						" 10	" 3	" 20	18	8.0	1.40	2.64
"						" 2	" 3	Nov 23				.94
Clay L.				" 8	2	Apr 20	M'y 4	" 6				1.19
Gravel "	30			" 8	4	M'y 24	Jun. 10	" 6				1.26
Loam						Jun. 20	Jul. 20	" 20	16			.75
"						" ..	" ..	" ..				1.04
"												1.21
Alluv'l L.						" 1		Oct. 20	18	8.5	1.44	1.57
"				"		" 14	" 7	" 20	16	9.0	.81	1.14
"				" 9	2	" 14		" 20	16	9.0	1.57	1.31
Sandy L.				" 6	6	M y 15	M'y 30	" 15				1.37
"	60	Vegetables.		" 7	3	Jun. 23	Jnl. 12	" 15	20	8.0	1.50	1.14

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			
						Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Chau., C'td							
87	M. Sackett	Irving....	20.4	15.85	77.7	15.06	301	26.79	8064
88	R. L. Newton...	“	18.8	14.90	79.3	14.16	283	26.24	7426
89	A. D. Burmaster	“	19.2	15.95	83.1	15.15	303	23.85	7227
90	Det. Dye	Forestvi'e	20.3	17.35	85.4	16.48	330	......	.. ...
91	E. J. Cole.......	“	21.1	17.25	81.7	16.39	328	.....	...
92	Chas. Barnes....	“	21.7	19.40	89.4	18.43	369	11.76	4339
93	E. H. Keyes....	“	20.4	16.65	81.6	15.82	316	......	......
94	F. A. Gron......	Jamestown.	17.0	13.60	80.0	12.92	258	......	......
95	A. A. VanVlick.	“	22.3	19.60	87.9	18.62	372	13.07	4862
96	B. W. Hayward.	“	19.9	15.80	79.4	15.01	300	......	......
97	Oscar Briggs....	SilverCr'k	22.2	19.60	88.3	18.62	372	18.00	6696
98	H. B. Clothier ..	“	20.8	18.00	86.5	17.10	342	......	......
99	Wm. H. Jacobs.	“	19.4	15.00	77.3	14.25	285	15.12	4309
100	E. Thomas......	“	20.2	17.00	84.1	16.15	323	...	......
101	“	“	20.2	17.40	86.1	16.53	331	.....	......
102	J. A. Kaiser	“	18.1	14.45	79.8	13.73	275	....	......
103	“	“	19.0	15.35	80.8	14.58	292	......	......
104	H. D. Wilson...	“	23.4	21.10	90.2	20.05	401	.....	......
105	O. L. Swift.....	“	18.8	15.20	80.8	14.44	289	......	......
106	“	“	20.4	17.00	83.3	16.15	323	......	......
107	W. T. Christy...	“	21.7	19.50	89.8	18.53	371	25.92	9616
108	M. J. Sackett...	“	19.2	16.45	85.7	15.63	313	......	......
109	R. S. Arnold....	Prospect..	22.5	20.40	90.7	19.38	388	19.70	7644
110	“	“	19.2	15.40	80.2	14.63	293	......	......
111	Mrs. B. B. Lord.	Sinclairv .	19.0	15.70	82.6	14.92	298	......	.....
112	A. B. Hawkins..	Ripley....	19.4	15.70	80.9	14.92	298	.... .	....
113	C. G. Brown....	“	18.1	14.10	77.9	13.40	268	22.11	5925
114	Mrs M Langw'rthy	Dunkirk .	20.8	16.25	78.1	15.44	309	14.59	4508
115	“	“	21.4	17.35	81.1	16.48	330	......	.. ...

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets, without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in...	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows...	Between beets in rows........	Harvested......	In samples analyzed......
Sandy L...	..	Potatoes...	'95	S., 6...	3	M'y 20	Jun. 7	Oct. 15	18	15.0	1.77	1.40
" ...	75	Vineyard..	....	" 7...	2	Jun. 14	Jul. 20	" 14	18	8.0	1.23	1.17
" ...	70	Corn	....	" 7...	2	M'y 24	Jun. 15	" 14	18	7.0	.96	1.35
" ...	..	....	....	"	2	" 23	" 22	Dec. 2	..	......	...	1.32
Gravel L..	..	Corn	'96	" 6...	..	" 15	......	Nov 16	..	......	....	....
" ..	50	Potatoes...	'95	" 7...	8	Jun. 4	Jun. 18	Oct. 13	20	7.5	.55	1.00
" ..	..	"	....	" 8...	.	M'y 1	Never	" 13	12	.....	....	1.12
Loam	20	....	....	....	..	Jun. 1	Jun. 20	" 13	..	......	....	2.92
Gravel L..	..	....	....	" 8...	7	M'y 26	.....	" 30	36	7.0	1.09	1.37
....	..	....	....	"	..	......	......	...	..	......	....	1.72
" ..	..	....	....	....	..	" 2	" 10	Nov 13	..	......	....	.77
" ..	..	....	....	....	..	" 5	" 5	" 13	..	......	...	1.20
Sandy L...	..	Potatoes...	'97	" 8...	2	Jun. 19	Aug. 6	" 5	18	6.0	.53	.76
Clay L...	..	....	....	" 8...	2	" 1	......	Oct. 22		.. ..	....	1.27
" ...	..	....	....	" 8...	2	" 1	......	" 22	..	......	....	1.40
Loam......	25	....	....	"......	..	M'y 6	Jun. 8	" 26	16	.....	....	2.25
....	..	....	....	....	..	......	......	......		.....	....	2.09
Clay L	..	....	....	....	..	M'y 25	......	" 29	..	......	...	.94
"	..	....	....	....	..	......	......	......	..	......	...	1.90
....	..	....	....	....	..	......	......	......	..	......	....	2.43
Gravel.....	60	Potatoes...	'97	" 7...	11	" 8	M'y 18	" 14	24	7.5	1.48	1.46
Muck L..	..	....	....	" 7...	..	Jun. 27	.... .	" 22	..	......	....	1.19
Clay " ..	..	Garden....	....	....	..	" 15	Jul. 28	Nov 30	18	10.0	1.14	.89
Muck " ..	..	....	....	....	..	......	......	......	..	......	....	.81
....	..	....	....	....	..	......	......	......	..	......	....	1.29
Dark " ..	..	Grapes. ...	....	....	..	" 1	" 10	Dec. 4	..	......	...	1.56
Muck " ..	20	Potatoes...	'96	" 8...	2	" 1	" 1	Oct. 9	24	8.0	1.37	1.71
Dark " ..	..	....	....	....	5	M'y 28	" 17	Nov 20	36	4.0	2.03	1.29
....	..	....	....	....	..	......	......	......	..	......	....	1.14

Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns: Per ct. sugar in the beet.	Beets without crowns: Pounds of sugar per ton beets.	Beets without crowns: Yield per acre of beets. Tons.	Pounds of sugar per acre.
	Chau., C'td							
116 R. T. Rolph	Dunkirk	20.3	17.15	84.4	16.29	326	......	......
117 "	"	21.9	18.85	86.1	17.91	358	.....	......
118 M. M. Fenner...	Fredonia .	21.7	19.10	88.0	18.15	363	54.56	19805
119 "	"	21.2	19.50	91.9	18.53	370	......	.....
120 H. D. Pangborn.	"	20.1	17.65	87.8	16.77	335	......	.....
121 "	"	21.0	18.75	89.3	17.81	356	......	.....
122 F. W. Howard.	"	21.4	18.50	86.4	17.58	351	...	......
123 C. E. Edmunds.	"	19.1	16.87	88.5	16.03	321	16.99	5454
124 S. S. Crissey....	"	20.4	16.70	81.9	15.87	317	19.82	6283
125 Thos. Moran....	"	23.7	20.65	87.2	19.62	392	13.29	5210
126 John Thies......	"	19.7	16.60	84.3	15.77	315	20.91	6587
127 J. J. Parker.....	"	19.5	15.65	80.3	14.87	297	22.32	6629
128 M. M. Fenner...	"	18.5	16.35	88.3	15.53	311	......	......
129 "	"	18.5	17.00	91.9	16.15	323	......	......
130 P. M. Elmer....	Stockton .	22.3	18.70	83.9	17.77	355	......	.....
131 "	"	23.2	19.05	82.1	18.10	362	11.13	4029
132 A. J. Swart	Sherman .	21.2	18.20	85.9	17.29	346	16.99	5879
133 R. E. Bliss......	"	17.9	13.50	75.4	12.83	256	......	......
134 F. A. Kelsey....	Westfield .	21.7	19.85	91.5	18.86	377	30.49	11497
135 Thomas Craigg.	"	19.7	15.00	76.1	14.25	285	20.77	5919
136 V. E. Saunders.	"	24.3	21.00	86.4	19.95	399	18.08	7214
137 S. G. McEwen..	"	18.3	13.10	71.5	12.45	249	12.63	3145
138 Harlon Munsen.	"	20.1	15.60	77.6	14.82	296	14.81	4384
139 A. N. Munsen..	"	21.4	18.45	86.2	17.53	351	12.13	4258
140 "	"	20.6	17.10	83.0	16.25	325	......	.....
141 Sam Craft.......	"	21.0	17.30	82.4	16.44	329	24.39	8024
142 J. H. Damm ...	"	21.7	18.00	82.9	17.10	342	13.42	4590
143 W. H. Beedle...	"	19.3	16.67	86.3	15.84	317	13.07	4143
144 T. E. Denison...	"	22.1	20.45	92.5	19.43	389	10.07	3917
145 A. Kelsey.......	"	18.5	13.60	73.4	12.92	258	12.94	3339
146 J. LaFlamboy...	"	19.8	17.25	87.1	16.39	328	28.23	9259

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows..	Between beets in rows........	Harvested......	In samples analyzed ......
Sandy L.	..	....	....	F. & S.	..	Jun. 20	.....	Nov 12	..	....	....	2.07
....	..	....	....	....	..	....	....	....	..	....	....	1.14
Black "..	21	Oats	....	....	5	" 4	Jul. 2	" 5	30	....	....	1.84
....	..	....	....	....	..	....	....	....	..	....	....	1.23
Clay "..	..	Potatoes ...	'96	....	..	M'y 15	......	" 13	..	....	....	3.37
....	..	....	....	....	..	....	....	....	..	....	....	1.18
....	..	....	....	....	..	....	....	....	..	....	....	1.18
Loam	15	....	'97	S.	5	Jun. 1	" 7	" 12	36	7.0	1.41	1.02
Sandy "..	40	Cabbage...	....	" 6	6	M'y 27	Jun. 16	Oct. 13	30	7.5	1.44	1.72
Gravel "..	40	Carrots....	'95	"	3	" 25	" 20	" 12	20	8.5	.73	.84
Sandy "..	40	Sweet Corn	'95	" 7	6	Jun. 1	" 22	" 13	24	7.0	1.13	1.24
Clay "..	70	Onions	'95	" 9	5	M'y 8	M'y 25	" 13	28	9.0	1.83	1.70
....	..	....	....	....	..	....	....	....	..	....	....	3.41
....	..	....	....	....	..	....	....	....	..	....	....	1.43
....	..	....	....	....	..	....	....	....	..	....	....	1.02
Clay "..	..	Garden....	'96	"	4	M'y 19	Jun. 12	" 25	20	14.5	1.04	1.42
" "..	.	....	'97	....	..	" 10	Jul. 23	Nov 20	18	11.0	1.08	.79
" "..	..	....	'97	....	..	Jun. 20	" 21	" 6	..	....	....	.99
Gravel "..	..	....	...	....	..	M'y 16	July	" 17	24	6.5	1.50	1.32
" "..	..	....	...	....	..	" 5	" 15	" 18	22	9.0	1.34	1.33
Sandy "..	..	....	...	....	4	" 10	" 22	" 18	22	....	....	1.13
Dark "..	..	....	...	....	..	" 10	" 14	" 10	36	5.5	.81	2.10
Gravel "..	..	Mangolds..	....	....	..	" 16	" 22	" 20	36	8.0	1.42	1.96
" "..	..	Garden....	....	....	3	" 16	" 22	" 20	30	7.0	.84	1.61
....	..	....	....	....	..	....	....	....	..	7.0	....	1.59
" "	.	Corn	....	....	..	" 5	" 18	" 20	36	8.0	2.28	1.00
" "	..	....	....	....	..	" 18	" 23	" 15	18	10.0	.80	.79
Clay "..	21	....	...	......	1	Jun. 16	" 17	" 12	36	10.0	1.50	.99
" "	..	....	'97	F & S 9	1	" 5	" 17	" 10	30	24.0	1.36	.63
Muck	..	....	....	....	..	Jul. 1	Aug. 1	" 8	36	6.0	.90	1.43
Clay "..	.	....	'97	....	..	Jun. 3	Jul. 15	" 5	30	.....	...	1.33

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			
						Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets Tons.	Pounds of sugar per acre.
		Chau.,C'td							
147	Ottaway Bros...	Westfield.	22.2	19.20	86.5	18.24	365	17.99	6566
148	H. Shaw........	"	20.6	17.65	85.7	16.77	335	26.13	8754
149	O. Freeling.....	"	20.3	16.28	80.1	15.47	302	22.87	6907
150	S. M. Hosier..	"	21.7	19.55	90.3	18.57	371	11.33	4203
151	D. W. Hall.....	"	19.0	15.35	80.8	14.58	292	12.26	3580
152	Wm. Schrader..	"	21.9	18.95	86.5	18.00	360	27.88	10037
153	F. W. Foster...	"	21.2	17.15	80.9	16.29	326	16.73	5454
154	P. G. Phillips...	"	22.2	17.75	80.0	16.86	337	13.29	4479
155	F. R. Thompson	"	17.0	13.30	78.2	12.64	253	26.46	6694
156	J. W. Spencer..	"	22.2	18.35	82.7	17.43	349	......	......
157	E. Saunders....	"	23.3	19.00	81.5	18.05	361	11.16	4029
158	F. A. Hall......	"	18.8	14.50	77.1	13.78	376	......	......
159	C. R. Colburn..	"	19.4	16.45	84.8	15.63	313	22.43	7021
160	H. L. Kent.....	"	20.3	18.00	88.7	17.10	342	19.60	6703
161	"	"	19.2	15.65	81.5	14.87	297	......	......
162	F. L. Monfort .	Portland..	21.0	17.50	83.3	16.63	332	7.18	2384
163	D. W. Douglas..	" .	18.5	13.30	86.2	12.64	253	......	......
164	"	"	21.7	16.60	83.0	15.77	315	....	......
165	F. McGinnis....	" .	18.6	14.80	79.6	14.06	281	......	......
166	R. D. Burhans	" ..	20.4	16.85	82.6	16.01	320	4.85	1552
167	R. F. Sternburg.	Frewsburg	19.5	16.05	82.3	15.25	305	18.51	5646
168	S. Townsend....	"	22.3	19.40	87.0	18.43	369	13.07	4823
169	W. Judd........	Hamlet...	17.2	13.10	76.2	12.45	249	10.35	2577
170	"	" ...	15.9	11.75	73.4	11.16	223	......	......
171	C. A. Weaver.	D'Wittv ll	22.2	19.00	85.6	18.05	361	12.89	4653
172	M. P. Nevins...	Smith's M	19.7	16.10	81.7	15.30	306	20.26	6200
173	T. H. Roberts...	"	21.9	19.50	89.0	18.53	371	......	......
174	E. R. Howard..	"	21.7	18.05	83.2	17.15	343	12.94	4438
175	J. Overhiser....	"	21.2	18.30	86.3	17.39	348	......	......
176	A. P. Stone.....	"	23.2	21.00	90.5	19.95	399	......	......

Character of soil.				Character of cultivation.		Dates of			Distance Inches.		Avg. wt. of beets, without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows..	Between beets in rows........	Harvested......	In samples analyzed......
Loam.		Turnips	'97		6	Jun. 4	Jul. 20	Nov 17	20	6.5	.76	.70
Gravel L.			'97		4	" 5	" 15	" 15	18	8.0	1.22	1.32
" "		Mangolds.	'97		5	" 8	" 15	" 12	24	7.5	1.31	1.09
Dark "		Hay		S., 7	2	" 4	" 20	" 15	36	12.0	1.53	1.39
Clay "		Potatoes	'97			" 5		" 18	22	7.5	.61	1.29
Gravel"		Corn	'97		6	" 10	" 25	" 12	30	5.0	1.33	2.06
Sandy "			'97			" 4	" 15	" 15	24	10.5	1.24	2.25
Clay "	60	Potatoes	'97	F	5	" 1	Jun. 21	Oct. 11	34	6.0	.87	1.31
" "		Sod.	'95	S., 8	3	" 5	" 18	" 9	24	8.0	1.66	1.82
Sandy "					2	" 1	" 17	" 9				1.14
Gravel"		Vegetables.	'94	S., 6	2	" 1	" 28	" 11	24	5.0	.44	.68
Clay "					4	" 10	" 25	" 23				2.43
Alluvial		Oats	'97		5	" 10	Jul. 10	Nov 10	30	9.0	1.84	1.46
Gravel"				"	3	" 2	" 10		30	6.5	1.25	1.63
												1.27
Gravel"				"	2	M'y 20	" 23	" 10	18	19.0	.80	1.24
Loam "	50	Carrots	'94	"	3	Jun. 14	" 26	" 13	18		1.04	1.75
												1.04
Clay "			'97			Jun. 10	" 15	" 5	30	8.5		1.87
Clay				"	4	M'y 25	Jun. 20	Oct. 1	36	8.0	.44	.43
Yellow"	25	Turnips	'97	S., 10	4	" 25	" 20	Nov. 1	36	6.5	1.42	1.26
Gravel"		Corn	'96	" 7	3	Jun. 7	Jul. 20	Oct. 30	36	7.5	1.15	1.42
Loam		Corn	'97			" 1	" 1	" 6	18	9.0	.53	.86
												4.94
Sandy "					5	Apr 20	Jun. 28	" 9	21			1.46
Clay "	60	Potatoes	'95	S., 8	6	M'y 24	" 9	" 14	24	10.5	1.63	1.33
Gravel						" 25						1.14
Sandy "		Sod.		" 9	3	Jun. 5		" 22	28	8.0	.91	.99
Clay "						M'y 25		" 22				.71
Dark "				" 7	2	" 25		" 22				.83

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			
						Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Chau., C'td							
177	E. B. Tolles.....	Sheridan .	19.2	16.15	84.1	15.34	307	14.15	4344
178	M. J. Tooke	"	19.2	16.05	83.6	15.25	305	......	......
179	Wm. Wallert ...	"	19.2	15.80	82.3	15.01	300	37.95	11385
180	E. E. Hamlet...	"	20.8	17.90	86.1	17.01	340	19.82	6739
181	L. Harmon	Brockton..	20.0	17.90	89.5	17.01	340	......	......
182	A. M. Gardner..	"	20.0	16.85	84.3	16.01	320	18.79	6013
183	D. G. Smith	Hanover. .	19.3	16.30	84.4	15.49	310	......	......
184	J. P. Clark......	Falconer .	21.5	18.00	83.7	17.10	342	16.90	5780
185	J. E. Bonney....	Irwin.....	20.4	16.50	80.9	15.68	314	......	......
		Erie.							
186	J. Buzenburg* ..	Brant. ...	18.1	15.00	82.9	14.25	285	11.87	3383
187	E. G. Fenton*..	Fenton...	16.5	13.00	78.8	12.35	257	28.75	7389
188	M. J. Brown*...	"	22.3	20.15	90.4	19.14	383	19.00	7277
189	J. Russell*......	"	22.5	19.50	86.7	18.53	371	......	......
190	Benj. Fenton * .	"	22.8	20.85	91.5	19.81	396	16.55	6554
191	"	"	20.1	18.10	90.0	17.20	344	16.55	5693
192	Jas. Bufton *....	"	22.5	20.35	90.4	19.33	387	......	......
193	J. A. Fenton*...	"	22.2	19.55	88.0	18.57	371	......	......
194	"	"	21.7	18.75	86.6	17.81	356	37.46	13336
195	E. G. Fenton *..	"	17.2	13.50	75.8	12.83	257	......	......
196	"	"	17.6	13.75	78.1	13.06	261	......	......
197	Wm. Krull * ...	"	19.1	15.80	82.7	15.01	300	27.01	8103
198	M. J. Brown *...	"	20.4	18.05	88.5	17.15	343	20.04	6874
199	"	"	22.0	19.85	90.2	18.86	377	......	......
200	"	"	20.4	18.50	90.7	17.58	352	....	......
201	"	"	21.9	20.85	95.2	19.81	396	15.25	6039
202	"	"	20.6	18.75	91.0	17.81	356	......	....
203	Geo. J. Martin*.	"	20.6	17.60	85.4	16.72	334	19.20	6413
204	P. Privater.*....	"	23.7	21.50	90.7	20.43	409	15.68	6413

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* Through the courtesey of Mr. C. M. Fenton, of the Erie Preserving Co., the Station has received samples of beets for analysis from the above "starred" parties.

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows..	Between beets in rows........	Harvested......	In samples analyzed.......
Gravel L..	85	Sod.	'95	S., 6..	4	M'y 25	Jun. 10	Oct. 13	24	9.5	1.05	1.07
“	85	Potatoes...	...	....		“ 26	Never	“ 13	..	.....	....	.75
Clay “..	30	Onion's....	'97	“ 7..	..	Jun. 15	Jul. 10	Nov. 9	18	7.5	1.63	1.47
Gravel “..	75	....	....	....	2	“ 2	....	“ 5	21	6.5	.84	1.17
Sandy “..	..	....	....	....	..	M'y 26	Jul. 19	“ 12	..	.....	.	1.36
Clay “..	40	Potatoes...	'95	“ 5	4	“ 25	Jun. 16	“ 12	36	8.0	1.67	1.47
Gravel	..	....	...	“		....	....	Oct. 29	.	....	..	.70
Sandy “..	..	Garden......	...	“ 8	3	Jun. 5	Jul. 10	“ 9	24	7.0	.86	.55
Alluv'l “..	..	....	....	....	1	“ 22	.....	“ 23	..	.....	....	1.14
Sandy “..	50	Cabbage......	....	“	4	M'y 15	Jun: 8	Oct. 16	36	8.0	1.14	.67
Sandy L...	..	....	'97	S., ..	7	Apr 16	M'y 25	“ 21	30	9.0	2.54	2.31
“	..	Beans	....	“ 7..	2	“ 15	“ 20	“ 27	16	.....	..	.92
Clay L...	..	....	....	....	..	Jun. 1	Jul. 1	“ 25	..	....	...	1.13
“	20	....	.	“ 8..	..	M'y 25	Jun. 10	“ 13	18	9.0	.84	.79
“	20	....	....	“ 8..	..	“ 25	“ 10	“ 13	18	9.0	.84	.55
Sandy “...		....	....	....		“ 20	“ 15	“ 20	..	.....	....	1.05
Clay “...	...	....	....	....		“ 25	....	.....	..	....	....	.65
“	15	Peas, Beans	....	“ 8..	..	“ 25	“ 15	“ 5	18	8.0	1.76	1.09
....	....	....	....	....		.....	....	......		.....	....	2.72
.....	...	....	...	....		.....	.....	......	...	.....	....	5.46
Clay “...	30	....	....	“ 8	5	“ 8	M'y 20	“ 6	18	9.0	1.28	1.34
“	15	Peas.......	....	“ 8	..	Jun. 3	Jun. 20	Sep 26	18	7.5	.87	1.76
....	..	....		....		.....	.....	. .	...	.....	...	1.17
....	..	....	..	....		.....	.....	.....	...	.....	....	1.10
Clay “....	..	Peas.......	'96	“ 8..	3	M'y 25	“ 20	Oct. 12	18	8.0	.72	.69
“		....	....	....	.	“ 25	“ 20	Nov. 1	..	.....	...	1.16
Sandy “...	...	....	....	“ 8	2	Jun. 2	“ 24	Oct. 18	..	....	....	.91
Clay “...	22	Cereals	.....	“ 8	..	M'y 27	“ 26	“ 13	18	8.5	.75	.57

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			Pounds of sugar per acre.
						Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	
		Erie, C'td.							
205	Emery Coffram*	Fenton...	22.6	19.65	87.0	18.67	373	14.00	5222
206	W. Taft*.......	" ...	21.0	17.45	83.1	16.58	332	14.00	4648
207	J. H. Bragg. ...	S. Wales.	21.5	18.65	86.7	17.72	354	5.36	1897
208	Chas. Benson...	"	21.5	19.00	88.6	18.05	361	......	......
209	A. Wade, Jr ..	Farnham.	21.5	18.90	87.9	17.96	359	......	.....
210	Chas. N. Cook*	"	21.9	19.65	89.7	18.67	373	16.55	6173
211	Chas. Crawford*	"	19.5	16.15	82.8	15.34	307	21.33	6548
212	Wm. Thuerk*.	"	22.3	19.95	89.5	18.95	379	8.45	3203
213	Chas. Nertling*	"	20.6	17.25	83.7	16.39	328	....	......
214	J. C. Winters*..	Brant	20.2	18.90	93.6	17.96	359	17.04	6117
215	David George*..	"	18.6	13.60	73.1	12.92	258	......	......
216	J. Buzenburg*..	"	20.8	18.50	88.9	17.58	352	18.00	6336
217	"	"	20.8	18.80	90.4	17.86	357	18.00	6426
218	Mrs. F. Poodry*	"	20.3	15.85	78.1	15.06	301	......	......
219	J. C. Winters*..	"	21.2	19.05	89.9	18.10	362	9.58	3468
220	S. A. Parker*...	"	19.9	16.90	84.9	16.06	321	18.00	5778
221	E. H. Babcock..	Eden Cen.	19.3	16.50	85.5	15.68	314	......	.....
222	G. E. Kister....	"	19.3	15.65	81.1	14.87	297	26.68	7924
223	Wm. Taft	N. Collins.	19.5	15.40	79.0	14.63	293	14.60	4278
224	F. J. Quigley...	Collins...	21.2	18.45	87.0	17.53	351	......	......
225	A. Cervis*	Orchard P	20.8	18.05	86.8	17.15	343	14.16	4857
		Genesee.							
226	D. L. Graham..	Batavia...	19.1	15.60	81.7	14.82	296	10.34	3061
227	M. W. Oderkirk.	"	16.5	14.25	83.4	13.54	271	16.95	4593
228	John Moore.....	"	19.5	14.95	76.7	14.20	284	14.71	4178
229	W. R. Bigelow..	"	22.2	19.00	85.6	18.05	361	8.06	2910
230	Pratt Bros......	"	22.8	20.00	87.7	19.00	380	8.49	3226

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* Through the courtesy of Mr. C. M. Fenton of the Erie Preserving Co., the Station has received samples of beets for analysis from the above "starred" parties.

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows..	Between beets in rows.......	Harvested.....	In samples analyzed.....
Clay L.		Hay		S	6	M'y 20	Jun. 20	Oct. 12				.75
“ “						“ 25	“ 28	“ 13				1.27
Muck “	12	Turnips	'97	“	3	“ 18	“ 24	“ 28	36	7.0	.42	.64
“ “	50		'97	“ 7	3	Jun. 15	Jul. 20	Nov 20	16	5.0		.60
Clay					2	“ 6	“ 1	Oct. 13	18			.89
Bottom L.	15			“ 8		M'y 17	“ 1	“ 12	18	12.5	1.19	1.20
Sandy “	20			“ 8	3	“ 27	“ 18	Nov 6	18	9.0	1.08	1.21
“ “				“	3	Jun. 10	“ 10	“ 12	22	16.0	.94	.75
Clay “						M'y 23	Jun. 10	Oct. 20				1.43
Sandy “	30	Corn	'95	“ 6	4	“ 20	“ 16	“ 16	24	7.5	.98	.93
						Jun. 10	Jul. 1	“ 20				1.15
						M'y 26	Jun. 20	“ 13				.92
						“ 26	“ 20	“ 13				.68
						Jun. 25	Jul. 17	“ 20				.72
				“ 6	3	M'y 15	Jun. 10	“ 13	18	15.0	.83	.82
						“ 20	“ 25	“ 13				.60
Sandy “	40	Strawberr's		“ 5	1	Jul. 1	Jul. 18	“ 19				1.10
“ “	60	Corn	'96	Fall 5	4	Jun. 4	Jun. 27	“ 19	24	8.0	1.66	1.43
Heavy “		Potatoes	'97	S 6	2	M'y 20	Aug 10	“ 21	30		1.26	1.33
												.37
Sandy “	40	Garden	'97	“ 4	4	“ 20	Jul. 7	Nov 15	18	8.0	.66	.66
Dark “		Beets	'97	“	5	Jun. 1	Jul. 27	Oct. 9	28	9.0	.83	1.00
Sandy “			'97	“ 8	5	M'y 24	Jun. 27	“ 13	18	8.0	.73	1.09
“ “					1	Jun. 3	Jul. 29	Nov 18	19	14.0	1.27	.96
Clay	50	Sod		“	8	M'y 20	Jun. 25	Oct. 16	36	11.5	1.09	.70
“		Alfalfa		“ 8	3	“ 27		“ 9	18	11.0	.54	.50

						Beets without crowns.			
	Name.	County.	Brix° or per ct. solids in the juice	Per ct. sugar in the juice.	Purity. Per cent.	Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Gen., C'td							
231	O. Marsh	Batavia	20.0	16.00	80.0	15.20	304	13.83	4204
232	Mrs. K. Slager	"	17.4	14.60	83.9	13.87	277	......	......
233	E. Hirsch	"	18.6	14.85	79.9	14.11	282	11.41	3218
234	L. O. Campbell	"	21.5	17.20	80.0	16.34	327	15.43	5046
235	H. Huntington	"	19.7	16.15	82.0	15.34	307	11.47	3521
236	A. Prole	"	19.7	15.35	77.9	14.58	292	7.29	2129
237	H. Putnam	"	17.7	14.00	79.1	13.30	266	16.06	4272
238	C. Brumsted	"	19.5	16.20	83.0	15.39	308	11.94	3678
239	J. G. Fargo	"	19.7	15.60	78.6	14.82	296	15.63	4626
240	W. N. Torrence	"	17.9	14.00	78.2	13.30	266	9.80	2607
241	H. L. Foster	"	19.3	16 20	83.9	15.39	308	11.81	3637
242	C. Pratt	"	23.7	19.40	80.0	18.43	369	13.07	4823
243	C. L. Gillett	"	17.2	13.35	77.6	12.68	254	15.85	4026
244	O. Harris	"	19.3	15.15	78.5	14.39	288	20.88	6013
245	A. G. Collins	"	18 6	14.90	80.1	14.16	283	7.26	2055
246	L. Scoville	"	19.5	16.70	85.7	15.86	317	4.19	1328
247	E. O. Bratt	"	20.2	17.05	84.4	16.20	324	12.03	3898
248	J. F. Post	"	20.6	17.90	86.9	17.00	340	10.97	3730
249	W. Tyrell	"	19.3	16.05	83.1	15.25	305	3.32	1013
250	G. Hayden	"	20.0	17.60	88.0	16.72	334	7.20	2405
251	W. S. Spink	"	17.9	14.90	83.2	14.16	283	......	......
252	W. H. Uphill	W. Batavia	19.3	16.30	84.5	15.49	310	15.30	4743
253	Wm. Heywood	Stafford	20.0	17.00	85.0	16.15	323	10.78	3482
254	"	"	19.5	15.90	81.6	15.11	302	10.78	3256
255	J. S. Combs	"	20.9	17.55	84.9	16.68	334	14.59	4873
256	J. F. Stutterd	"	19.1	15.10	79.1	14.35	287	11.43	3280
257	R. Call	"	20.0	16.90	84.5	16.06	321	11.11	3566
258	Jas. Linsler	"	19.8	16.40	82.8	15.58	312	12.41	3872
259	Jno. Heywood, Jr	"	20.8	17.55	86.3	16.68	334	6.64	2218
260	J. Lathrop	Morganv.	21.9	18.15	82.9	17.24	345	20.24	6983

Character of soil.				Character of cultivation		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows...	Between beets in rows........	Harvested....	In samples analyzed......
Marl			'95	S.	5	M'y 20	Jun. 16	Oct. 23	30	7.5	.99	1.52
Bl'k Muck					3	Jun. 1	" 15	" 23				1.51
Sandy L		Potatoes	'96	"	2	M'y 15	" 28	" 8	20	10.5	.77	1.36
"				" 8	3	" 10	" 10	" 9	22	7.5	.82	1.30
"		Potatoes		"	6	" 28	" 29	" 8	28	11.0	1.11	1.21
Gravel L					2	Jun. 1	Aug. 1	" 9	28	7.0	.51	.66
Loam					4	M'y 13	Jul. 3	" 6	28	10.0	1.44	1.76
Gravel L					6	" 2	Jun. 25	" 8	20	13.5	1.05	1.31
Sandy "	75	Nurs'ry Stk	'95	" 9	5	Jun. 2	" 14	" 8	32	7.0	1.14	1.56
"	45	Grass		" 7	6	M'y 25	Jul. 12	" 8	36	11.5	1.32	1.37
"		Corn	'97	" 7	3	" 20	" 10	" 8	18	8.5	.54	.93
Gravel L				"	2	Jun. 1	" 7	" 5	30	8.0	.97	.94
Alluv. "	10		'97		6	M'y 1	" 3	" 5	36	8.0	1.49	1.57
Sandy "	9		'97		5	" 10	" 10	" 6	28	8.5	1.60	1.45
Alluv. "		Sod	'97		6	Jun. 15	" 25	" 5	30	11.5	.81	1.29
Muck "					1	" 1	Late	" 4	18	8.5	.20	.20
Sandy "					3	M'y 15	Jul. 3	" 4	24	7.0	.63	.60
Gravel "	30		'97		4	" 20	" 10	" 5	36	8.0	1.03	1.06
Sandy "					7	" 25	"	" 5	30	17.0	.54	.75
Dark "								" 5	36	9.0	.78	.69
"								" 6				.65
Gravel "		Beets				Jun. 10	" 3	" 26	24	9.0	1.06	1.23
Loam				"	2			" 11	28	8.5	.81	1.07
"				"	2	" 5		" 11	28	9.0	.85	.95
Sandy "		Beets	'97	"				" 12	24	6.5	.74	1.04
"	100	Oats, Peas.	'97	"	5	M'y 20	Jun. 28	" 12	36	9.0	1.19	1.13
Dark "				"	3	" 27		" 12	28	8.5	.85	.96
Sandy "		Beets	'97	" 8	8	" 20	" 16	" 8	32	6.0	.79	1.13
"			'97	"	4	Jun. 15	Jul. 15	" 11	32	12.5	.85	.89
Clay "	80			"	6	" 10	Aug. 1	" 12	18	6.5	.76	.77

						Beets without crowns.			
	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Gen., C'td							
261	H. Radley......	Morgan V.	18.8	16.50	87.8	15.68	314	11.03	3463
262	J. W. Bater.....	"	19.2	16.10	83.8	15.30	306	16.60	5080
263	J. Simmons.....	"	21.3	17.50	82.2	16.62	332	......	......
264	T. O. Parminter	"	21.7	18.80	86.6	17.86	357	16.99	6065
265	Thos. Marsh....	Byron....	23.0	19.60	85.2	18.62	372	12.93	4810
266	W. A. Walker..	"	20.4	17.50	85.8	16.62	332	12.20	4050
267	I. W. White ...	"	20.4	18.00	88.2	17.10	342	23.52	8044
268	H. C. Norton...	"	18.5	14.50	78.4	13.77	275	15.40	4235
269	W. J. Tyler.....	S. Byron	19.3	15.15	78.5	14.39	288	18.08	5207
270	I. Durfee	"	18.6	14.60	78.5	13.87	277	12.75	3532
271	J. R. Norton....	Davis.....	17.2	13.80	80.2	13 11	262	13.39	3508
272	A. H. Olmstead.	LeRoy....	18.6	14.05	75.5	13.35	267	12.96	3460
273	Jas. Forsyth....	New Kirk	20.9	17.65	84.4	16.77	335	13.61	4559
274	J. R. Fotch. ...	"	20.4	17.10	83.8	16.25	325	5.93	1927
275	D. G. Frazer....	Alexander	18.8	14.65	77.9	13.92	278	11.39	3166
276	T. W. Fansen...	Bergen...	21.0	18.80	89.5	17.86	357	17.26	6162
277	J. C. O'Brien...	" ...	22.2	19.55	88.0	18.57	371	13.30	4934
278	C. W. Maybeck.	N. Bergen	22.3	18.95	85.0	18.00	360	8.17	2941
279	B. D. Harkness.	Elba.	20.6	17.85	86.6	16.96	339	12.20	4136
280	E. M Vail	E. Oakfied	21.5	17.75	82.6	16.86	337	......	......
281	J. Cleveland....	E.P'mbr'ke	21.0	18.40	87.6	17.48	350	16.39	5737
282	L. Mallory......	"	22.5	19.35	86.0	18.38	368	17.26	6352
283	L. F. Lyman....	"	18 8	15.35	81.6	14.58	292	14.48	4228
284	H. Beckwith....	N. "	19.7	15.85	80.5	15.06	301	16 83	5066
285	T. Harding.....	Bethany..	23.0	19.80	86.1	18.81	376	17.04	6407
286	W. M. Crawford	W.B'th'ny	22.1	18 60	84.1	17.67	353	11.33	3999
287	E. C. Norton...	"	19.9	17.05	85.6	16.20	324	16.67	5401
		Herkimer							
288	Wm. McKerrow	Middleville	17.5	13.85	79.2	13.16	263	16.77	4411

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets, without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations..	Planting.	Thinning.	Harvesting.	Between rows..	Between beets in rows.......	Harvested......	In samples analyzed......
Gravel L......		Clover.....	'95	S., 6..	4	M'y 25	Jun. 25	Oct. 13	34	10.0	1.17	1.16
Sandy "		....	'97	"	2	" 28	Jul. 10	" 13	18	9.0	.88	1.18
Lime rock....		....	....	....	..	....	......	" 20	..	......	....	1.19
Sandy L.....		....	....	"	1	Jun. 3	......	" 12	24	3.0	.42	.63
Loam.......		....	....	"	2	" 5	" 15	" 15	24	7.0	.68	1.04
Dark "		Corn	'96	" 7..	2	M'y 13	" 6	" 15	24	8.5	.81	1.15
Gravel"		Celery.....	..	S......	3	" 19	Jun. 25	" 15	24	6.0	1.06	1.29
Dark "		....	'97	" 8..	9	" 20	......	" 15	36	12.0	2.13	1.30
Gravel"		....	'95	" 9..	4	Jun. 15	Jul. 15	" 13	34	10.0	1.94	1.73
Stiff " ..	14	....	'97	" 9.	9	M'y 14	Jun. 10	" 13	36	12.0	1.75	1.28
Black "		Mangolds..	'96	"	2	" 20	" 25	" 5	2[illegible]	5.0	.44	.99
Loam		....	....	S......	5	" 25	Jul. 10	" 7	28	9.0	1.04	1.18
Gravel" ..	20	Beets.......	'94	" 8..	4	" 1	M'y 20	" 5	32	8.0	1.12	1.74
Clay " ..	70	Pasture.....	....	"	6	" 14	Jul. 10	" 5	32	6.5	.40	1.02
Stiff "		....	....	" 7..	6	Jun. 12	" 12	" 6	28	10.0	1.00	.91
Dark "		Mangolds..	'96	" 8..	8	....	......	......	22	10.0	1.52	1.08
Clay "		....	'97	" 8..	5	M'y 15	Jun. 15	" 14	28	7.5	.91	1.07
Sandy "		....	'95	" 8..	4	" 15	......	" 16	30	5.0	.38	.47
" " ..	40	Cabbage...	....	" 7..	3	" 19	Jul. 12	" 20	28	....		.92
....		....	....	....		......	" 5	" 20	24	....	1.00	1.14
Sandy "		....	....	....	..	Jun. 1	" 15	" 23	20	11.0	1.21	1.30
Loam......	65	T. Hay....	....	" 8..	3	M'y 29	Jun. 28	" 27	36	6.5	1.32	1.26
Sandy " ..	20	Mangolds..	...	" 7..	4	" 20	" 30	" 19	30	10.0	1.41	1.34
" "		Corn	'95	" 8..	5	" 20	Jul. 10	" 21	36	8.0	1.57	1.03
Clay " ..	3	Beets.....	. .	" 8..	3	Jun. 6	" 20	" 26	32	6.5	1.11	1.16
" "		Orchard...	'96	"	..	M'y 29	" 1	Nov. 5	36	9.0	1.14	1.13
Dark " ..	3	Corn	'97	" 8..	.	Jun. 5	......	Nov 10	18	6.0	.58	.60
Gravel"		Corn	....	" 9..	6	M'y 28	Jun. 30	Oct. 6	36	11	1.08	1.75

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			
						Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Jefferson.							
289	W. J. Tilley.....	Plessis....	22.0	18.65	84.8	17.72	354	......	.....
290	Frank Favery..	Chaumont	18.1	13.03	72.0	12.38	248	......	......
291	Geo. B. McMullin.	E. Hounds'f	19.5	16.80	86.2	15.96	319	21.78	6948
292	D. M. Greene...	Adams.. .	21.5	18.65	86.8	17 72	354	......	......
293	" ...	"	19.5	16.85	86.4	16.01	320	15.95	5104
294	" ...	" ...	16.5	13.00	78.8	12.35	247	......	......
295	" ...	"	17.7	14.50	81.9	13.78	276	......	......
296	" ...	"	18 3	15.00	82.0	14.25	285	......	......
297	" ...	"	19.5	16.35	83.8	15.53	311	......	......
298	" ...	" ...	19.9	17.40	87.4	16.53	331	......	......
299	" ...	"	18.8	16.25	86.4	15.44	309	......	.....
300	" ...	"	18.3	15.00	82.0	14.25	285	......	......
301	" ...	"	18.3	15.65	85.5	14.87	297	......	......
302	" ...	" ...	17 0	14.55	85.6	13.82	276	......	......
303	" ...	"	20.9	17.90	85.7	17.01	340	......	......
304	" ...	"	19.9	17.00	85 4	16.15	323	......	......
		Livingst'n							
305	C. D. Edwards..	N. Sparta.	22.5	19.25	85.6	18.29	365	10.45	3824
		Monroe.							
306	F. W. Brower...	Churchv..	19.7	18.45	93.6	17.53	351	.. ..	....
307	J. M. Carver....	"	21.7	19.10	88.0	18.15	363	12.41	4505
308	H. P. Dusinberry	"	19.4	16.55	85.3	15.72	314	12.35	3878
309	Jas. Easton.....	"	19.9	16.65	83.7	15.82	316	7.97	2519
310	G. A. Young....	"	19.5	15.85	81.3	15.07	301	14.95	4500
311	S. L. Payne.....	"	20.4	17.95	88.0	17.05	341	6.67	2274
312	J. L. Bangs......	"	18.3	15.55	85.0	14.77	295	13.94	4112
313	F. D. Palmer...	"	21.9	19.95	91.1	18.98	380	12.63	4799
314	A. McIntosh....	"	19.7	16.00	81.2	15.20	304	8.93	2715
315	C. W. Banister..	"	20.6	18.30	88.8	17.39	348	6.53	2272

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows...	Between beets in rows......	Harvested.....	In samples analyzed.....
Muck		Clover		F	6	Jun. 12		Oct. 11				1.34
Clay,					3	" 15	Jul. 28	" 28	16			1.31
Sand		Sod		" 7	3	M'y 21	Jun. 10	" 26	18	4.0	1.04	.81
					15			Nov. 3				.68
Gravel. L.		Beans		F. & S.	15	" 13		Oct. 4			1.89	1.54
"		"		"	15	" 13		" 4				1.56
"		"		"	15	" 13		" 4				1.49
"		"		'	15	" 13		" 4				1.79
"		"		"	15	" 13		" 4				1.37
Gravel "		Beans		"	8	M'y 13		" 4			1.84	1.43
"		"		"	8	" 13		" 4				1.25
"		"		"	8	" 13		" 4				1.88
"		"		"	8	" 13		" 4				1.62
"		"		"	8	" 13		" 4				1.09
Gravel "		Beans		"	15	" 13		" 4			1.80	1.42
" "		Beans		"	8	" 13		" 4			1.63	1.50
Clay "	40	Oats, Peas.	'97	S 6	1	" 18	Jun. 26	" 21	24	9.0	.73	.54
Sandy "	40	Corn	'95	" 8	1	Jun. 1	Aug. 4	" 14				.52
Clay "	60	Cabbage	'97	" 6	3	M'y 18	Jul. 20	" 15	28	10.0	1.11	.89
" "	65	Corn	'96	" 8	8	" 19	Jun. 16	" 15	30	8.0	.95	1.18
" "	50	Potatoes	'96	" 6	5	Jun. 3	Jul. 5	" 18	36	10.0	.82	.75
Sandy "				"	2	" 1		" 18	28	6.0	.84	1.06
" "				"	5	M'y 18	Jul. 15	" 18	36	8.0	.61	.77
Gravel "	60			" 10	6	" 8	" 10	" 15	30	9.0	1.20	1.02
Clay "	60	Cabbage	'96	" 7	3	" 13	" 25	" 16	24	15.0	1.21	.97
" "	65	Garden	'96	" 8	8	" 4	Jun. 10	" 15	30	7.0	.61	.98
" "	65			" 5	7	" 18	Jul. 5	" 14	32	8.0	.64	.90

	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			
						Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Mon., C'td.							
316	Geo. Savage	Churchv .	20.4	17.30	84.8	16.44	329	26.48	8712
317	Hiram Sage	"	21.2	17.05	80.4	16.20	324	21.13	6846
318	Wm. Bailey.....	"	21.9	19.65	89.7	18.67	373	15.03	5606
319	Spencer Day ...	"	23.0	20.40	88.7	19.38	388	19.27	7477
320	C. M. Emery ...	"	20.6	17.60	85.4	16.72	334	12.58	4202
321	J. Robertson ...	"	22.6	18.90	83.6	17.96	359	12.20	4380
322	H. J. May	"	22.0	18.40	83.6	17.48	350	11.94	4179
323	L. D. Bangs	"	21.3	17.25	81.0	16.39	328	17.26	5661
324	Henry Dewey...	"	20.6	17.10	83.0	16.25	325	17.42	5662
325	E. S. Parnell ...	"	17.2	12.85	74.7	12.21	244	......	......
326	" ...	"	17.0	12.90	75.9	12.26	245	......	......
327	" ...	"	19.3	16.15	83.7	15.34	307	......	......
328	Jas Wilson......	"	20.8	17.85	85.8	16.96	339	13.96	4732
329	F. T. Kurtz.....	"	19.7	15.75	80.0	14.96	299	15.79	4721
330	T. Perry........	"	20.8	18.50	88.9	17.58	351	9.47	3324
331	W. Lehman.....	"	20.6	18.45	89.6	17.53	351	19.11	6708
332	Geo. Brodie	"	21.5	18.40	85.6	17.48	350	7.19	2517
333	Thos. Dick	"	18.6	17.50	94.1	16.63	323	12.52	4044
334	Geo. Stewart ...	"	17.0	13.95	82.1	13.25	265	7.94	2104
335	C. Schneiter....	"	21.7	18 20	83.9	17.29	346	14.15	4896
336	H. W. Davis....	"	21.3	18.70	87.8	17.77	355	22.32	7924
337	A. Bebee	Riga	20.0	14.40	72.2	13.68	274	10.45	2863
338	Wm. Bell.......	"	21.9	18.85	86.1	17.91	358	14.54	5205
339	Chas. Lear.	"	23.9	20.10	84.1	19.10	382	13.47	5146
340	J. A. Moule.....	"	19.5	15.20	78 0	14.44	289	11.68	3376
341	John Amesbury.	"	21.9	16.75	76.5	15.91	318	......	......
342	John Brodie	"	19.7	16.45	83.5	15.63	313	14.32	4482
343	A. A. Palmer ...	"	21.0	17.35	82.6	16.48	330	20.69	6828

Character of soil.				Character of cultivation		Dates of			Distance Inches		Avg. wt of beets without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in..	When plowed and depth. Inches	No. cultivations..	Planting.	Thinning.	Harvesting.	Between rows...	Between beets in rows........	Harvested	In samples analyzed......
Clay L....	65	Mangolds	'96	S., 9..	3	M'y 10	Jun. 21	Oct. 16	18	10.5	1.54	1.23
“	70	....	'96	“ 8..	3	“ 18	“ 20	“ 19	16	6.5	.69	1.07
“ ...	65	Cabbage..	'96	“ 8..	6	“ 7	“ 16	“ 19	24	9.0	1.07	1.07
Sandy L...	65	Potatoes....	....	“ 8..	4	“ 11	“ 12	“ 16	16	6.0	.62	.76
Black M'rl.	25	“ ...	'96	“ 7..	3	“ 20	Jul. 19	“ 16	16	10.0	.66	.63
Clay L..	70	....	...	“ 8..	6	“ 10	Jun. 25	“ 19	32	9.0	1.08	1.17
“	70	Cabbage....	....	“ 11..	5	“ 12	“ 10	“ 14	32	6.5	.73	1.12
“ ...	65	Potatoes...	'92	“ 9..	3	“ 21	“ 20	“ 14	28	7.5	1.14	1.05
“	20	....	....	“ 8	5	“ 16	“ 12	“ 14	28	12.5	1.95	1.46
“	20	....	'96	“ 6 .	1	“ 18	“ 22	“ 19	...	...	...	1.74
Sandy L...	20	....	...	“ 6..	1	“ 18	“ 22	“ 19	...	...	...	.95
Black “...	15	Oats	'97	“ 8..	..	“ 18	Jul. 19	“ 19	...	...	...	1.02
Clay “...	...	....	....	“ 6..	8	“ 16	Jun. 20	“ 18	36	5.0	.84	1.12
Light “...	65	Cabbage...	'95	“ 7..	5	“ 5	“ 12	“ 19	30	7.5	1.12	1.06
“ ...	60	Grass	'96	“ 7..	4	“ 15	Jul. 10	“ 16	28	15.0	1.28	.98
Clay “...	50	Potatoes...	'97	“ 7..	5	“ 20	Jun. 20	“ 16	28	9.5	1.62	1.03
“ ...	65	Corn	'96	“ 7..	6	“ 20	Jul. 6	“ 15	28	10.0	.65	.91
Loam. ...	...	....	'96	S.&F. 8	4	“ 21	“ 1	“ 14	30	7.5	.90	1.00
Clay L....	50	Mangolds..	....	S., 8	4	“ 4	“ 3	“ 19	33	12.5	1.12	.85
“	65	Hay........	....	“ 7	6	“ 20	Jun. 30	“ 19	32	10.5	1.54	1.07
Lime St.	...	....	'94	S., 10..	3	“ 14	......	“ 14	18	7.5	.95	.97
Clay L.....	65	....	'92	“ 7..	7	“ 24	Jul. 2	“ 18	36	9.5	1.17	.99
“ ...	...	....	....	“	7	“ 15	......	“ 19	24	7.5	.82	.92
Muck L...	...	....	...	“	5	“ 24	......	“ 14	30	7.0	.87	.84
“ ...	30	....	....	“ 8..	3	Jun. 3	“ 15	“ 19	28	14.0	1.45	1.21
Clay L....	65	Corn	'93	“ 8..	8	M'y 15	Juu. 16	“ 18	...	...	...	.80
Stiff “....	...	....	'97	“	6	“ 21	......	“ 19	30	8 0	1.08	1.22
Clay “....	65	....	'92	“ 9..	5	“ 7	“ 10	“ 18	28	8.0	1.58	1.34

						Beets without crowns.			
	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
		Mon., C'td.							
344	D. D. Church...	Riga....	19.7	16.00	81.2	15.20	304	19.06	5794
345	C. F. Apthorp..	"	19.2	15.70	81.8	14.92	298	15.19	4527
346	John Atwater...	"	20.4	17.30	84.8	16.44	329	......	......
347	Geo. A. Johnson	"	20.4	16.15	79.1	15.34	307	19.82	6085
348	Geo. McConell..	"	21.0	17.00	81.0	16.15	323	15.66	5058
349	R. Garrison....	Brockport	20.5	17.15	83.6	16.29	326	10.67	3478
350	G. W. Sime.....	"	20.9	17.80	85.2	16.91	338	18.73	6331
351	W. H Dobbin..	Fairport..	......	15.35	76 0	14.58	292	......	......
352	A. W. Lumdell..	Rochester	......	18.90	90.9	17 96	359	......	......
353	Brown Bros. Co..	"	18.8	15.55	82.7	14.77	295	......	......
354	M. B. Batcheller	Webster..	21.7	18.00	82.9	17.10	342	23.96	8194
355	H. S. Curtis....	Ridgeland	18.1	13.75	75 9	13.06	261	9.37	2446
356	J. B. Johnston..	Chili Sta.	23.3	18.10	81.9	17.19	344	14.48	4981
357	G. Denel........	N. Chili.	19.9	17.10	85.9	16.25	325	24.83	8070
358	A. Fairbanks...	"	20.4	17.45	85.5	16.58	332	13.45	4465
359	M. H. Cusick...	Clarkson .	26.3	21.70	82.5	20.62	412	15 90	6551
360	Mrs. L. Patterson	"	18.8	14.80	78.7	14.06	281	21.78	6120
361	Ara Wilkinson..	"	21.1	17.70	83.9	16.82	336	17.64	5927
362	"	"	21.1	17.75	84.1	16.86	337	13.61	4587
363	Geo. P. Hill....	Ogden....	18.6	15.75	84.7	14.96	299	21.78	6512
364	J. C. E. Hill ..	"	18.5	17.00	91 9	16.15	323	15.48	5000
365	H. D. Scribner..	"	21.7	19.10	88.0	18.15	363	23.74	8618
		M'tg'm'ry							
366	A. VanAlstine..	Canajoharie	17.2	12.90	75.0	12.26	245	......	......
367	J. W. Shults....	"	20.0	16.85	84.3	16.01	320	......	......
368	E. Countryman..	"	19.7	15.50	78.7	14.73	295	......	......
		Niagara.							
369	Lockner & Delaney	Lockport.	20.4	15.80	77.5	15.01	300	......	......
370	R. Bewley.....	" ..	21.9	18.20	83.1	17.29	346	27.00	9342

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Av. wt. of beets, without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manure last applied in	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows.	Between beets in rows........	Harvested.....	In samples analyzed........
Clay L	70		'95	S., 9	6	M'y 26	Jul. 1	Oct. 16	28	9.0	1.56	1.02
Alluv. L				" 8	4	" 10	Jun. 16	" 16	28	6.0	.75	1.34
Clay "				S.	6	" 10		" 15				1.36
" "				S., 8	7	" 15	Jun. 15	" 14	28	7.0	1.32	1.39
" "				" 8	5	" 16		" 19	30	8.0	1.24	1.34
" "	75	Grass	'96	" 9	10	" 25	" 26	" 11	28	10.0	.94	.98
Gravel L		Beans	'96	" 7	6	Jun. 2	Jul. 3	" 12	24	9.0	1.28	.96
												1.82
												1.63
												1.65
Sandy L	20	Garden	'97	S., 4	4	M'y 15	Jun. 15	Nov. 5	20	9.0	1.37	1.24
Black "		Onions			7	Jun. 11	Jul. 28	Oct. 21	30	8.0	.72	.76
Clay "		Corn	'94	F&S., 7	6	M'y 7	Jun. 10	" 5	24	8.0	.85	.94
Dark "	18	Carrots	'96	S., 8	5	" 10	Jun. 14	" 14	28	7.0	1.52	1.64
Clay "	60	Hog yard		" 8	8	" 10	Jul. 12	" 16	30	9.5	1.26	1.12
" "	65	Beets	'96	" 8	7	" 8	M'y 24	" 13	20	9.5	.99	1.11
" "	80		'97	" 6	11	" 25	Jun. 25	" 10	24	8.5	1.43	1.52
" "	75	Beans		" 7	4	" 3	" 9	" 10	36	10.0	2.02	1.33
Black "	75	Cabbage		" 7	3	" 3	" 9	" 10	24	8.0	.83	.85
Sandy "		Potatoes				" 10		" 21	24	7.0	1.16	.97
" "						" 8		Nov. 3	18	5.5	.48	.65
" "			'97			" 5		Oct. 22	18	11.0	1.51	1.24
												1.31
												.74
												1.41
Sandy L	10	Beans		S.	2	Jun. 5	Jul. 10	" 10	30	12.0		1.62
Clay "	22		'97	S., 9	8	M'y 14	Jun. 15	" 18	30	9.5	2.50	2.00

Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns.			
					Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
	Niag., C'td							
371 Peter Faling...	Gasport .	21.1	18.35	87.0	17.43	349	42.14	14707
372 C. H. Whitcomb.	W. Sum'rs't	19.9	17.70	89.9	16.82	336	18.07	6072
373 A. M. Bennet...	Barkers ..	19.5	16.50	84.6	15.68	314	......	......
374 E. L. Ellis......	"	21.3	16.90	79.3	16.06	321	37.73	12111
375 J. T. Mellirt....	"	21.2	17.70	83.5	16.81	336	......	......
	Oneida.							
376 Geo. W. Brown.	Vernon C.	19.7	16.85	85.5	16.01	320	5.23	1674
377 C. Gleason......	Clinton ..	21.9	19.65	89.7	18.67	373	31.00	11563
	Onondaga							
378 W. H. Ellison.	Baldwinsv	20.1	17.40	86.6	16.53	331	13.07	4326
	Orleans.							
379 W. J. Strickland.	Albion ...	20.8	20.00	96.1	19.00	380	16.34	6209
380 " "	"	19.4	16.20	83.5	15.39	308	......	......
381 Briggs Applin..	Waterport	20.0	15.75	78.7	14.96	299	......	......
	Oswego.							
382 N. W. Adams...	Bundys C.	19.0	14.45	76.1	13.73	275	18.56	5104
	Saratoga.							
383 John Randall...	Corinth ..	23.4	20.25	86.6	19.24	385	16.38	6306
	Schuyler.							
384 B. Stephens	Beaverd'ms	20.0	15.50	77.5	14.73	295	15.29	4511
385 Mrs. C. Stephens	"	20.8	17.05	81.9	16.20	324	26.14	8469
	Seneca.							
386 John Anderson..	Magee ...	18.1	14.10	77.9	13.40	268	12.63	3385
387 John Dickerson.	Farmer ..	19.7	16.40	83.2	15.58	312	21.34	6658
388 Dr. A. Alleman.	McDougals.	20.8	17.58	84.5	16.70	334	....	......
389 "	"	21.0	17.50	83.3	16.63	323	.....	.....
390 Joe Jennings..	Romulus .	19.9	17.35	87.2	16.48	330	12.09	3990
	Steuben.							
391 Oscar Wheeler..	Hornellsv.	19.2	16.55	86.2	15.72	314	21.13	6635
392 Frank Marley...	"	18.6	16.10	86.5	15.30	306	35.06	10728

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows..	Between beets in rows.......	Harvested......	In samples analyzed......
Gravel L..		....	'97	S. & F. .		M'y 10	Jun. 12	Oct. 18	28	5.5	2.00	1.12
Sandy “..	30	Corn	'96	S., 10..	9	“ 27	“ 12	“ 25	28	9.0	1.43	1.31
Heavy ...	..	....	....	....	..	Jun. 15	Jul. 10	“ 23	16	.....	....	1.64
Muck “...	..	....	....	F	5	“ 6	“ 8	“ 19	18	9.0	2.00	1.02
Sandy “....		....	....	....	6	“ 5	“ 3	“ 16	18	7.0	....	.78
Clay “...	..	....	..	....	..	“ 5	......	“ 22	..	.....	....	.74
Black “...	..	....	..	....	..	M'y 20	Jun. 25	“ 13	..	....	...	.98
Clay “...	..	....	'96	S	3	Jun. 8	Jul. 10	“ 18	30	12.0	.73	1.53
Gravel “	50	Corn	...	F. & S.	..	“ 11	Jun. 20	Nov 4	30	9.0	1.41	1.52
....	..	....	..	....	..	....	....	....	..	.....	....	1.46
....	..	....		....	..	....	....	....	..	.....	....	1.13
Clay “....		Cabbage..	'95	S	6	Jun. 8	Jul. 5	Nov 18	24	6.0	.87	1.44
Sandy “....	.....	....	....	“ 8..	6	M'y 14	“ 6	Oct. 22	16	7.0	.56	.54
Shale	40	Strawberr's	....	“	2	“ 15	Jun. 10	“ 7	30	6.0	.87	.97
Clay L..	40	Potatoes ..	'96	“ 5	2	“ 28	“ 25	“ 28	16	7.5	1.50	1.11
Clay “..	70	Garden.....	'95	“ 8..	8	“ 18	“ 30	“ 21	36	8.0	1.18	1.28
“ “..	7	Beets......	'97	F. 8..	4	“ 16	“ 15	“ 20	18	7.5	.90	.84
“ “..	80	Potatoes...	'95	....	4	“ 15	Jul. 15	Nov 5	..	.....	....	....
“ “..	..	“	'95	....	7	“ 15	“ 15	“ 5	..	.....	....	...
Muck	..	....	....	S	5	“ 19	Jun. 20	Oct. 10	36	7.0	.96	.85
Sandy L..	..	....	....	....	2	“ 18	.....	“ 23	36	10.5	2.62	.88
Loam	..	Carrots....	...	S	..	“ 14	Jun. 15	“ 7	18	7.0	1.40	1.17

						Beets without crowns.			
	Name.	County.	Brix° or per ct. solids in the juice	Per ct. sugar in the juice.	Purity. Per cent.	Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons	Pounds of sugar per acre.
		Steub. Ct'd							
393	Pomeroy Smith.	Coopers P.	20.4	16.20	79.4	15.39	308	14.59	4494
394	Mrs. C. Harrison	Canisteo ..	20.8	18.50	88.9	17.58	352	11.97	4213
395	A. L. Ryndirs...	Cohocton.	19.9	17.20	86.4	16.34	327	......	......
396	Casper Shults...	"	19.0	14.20	74.7	13.49	270	......	......
397	H. P. Wilcox...	"	18.3	14.70	80.3	13.97	279	......	......
398	R. W. Milly	"	19.2	14.95	77.8	14.20	284	......	.....
399	C. Merz.........	"	20.6	17.15	83.2	16.29	326	.....	.....
400	S. W. Newman.	"	23.0	19.80	86.1	18.81	376	......	......
401	Jas. Stanton	"	17.4	15.35	88.2	14.58	292	......	......
402	M. Wager	"	21.5	17.75	82.5	16.86	337	......	......
403	A. P. Rocher...	"	18.6	13.50	72.5	12.83	257	......	......
404	W. Courtney....	"	21.9	19.00	86.7	18.05	361	......	......
405	F. A. Tobias....	"	21.5	19.45	90.4	18.48	370	......	......
406	Webster Edmunds	"	18.1	14.00	77.3	13.30	266	......	......
407	W. L. Rowe	"	18.3	15.60	85.2	14.82	296	......	......
408	E. W. Bentley..	"	17.4	13.60	78.2	12.92	258	......	......
409	Phil. Sich	"	19 5	15.20	78.0	14.44	289	......	......
410	J. G. Stirble....	"	18.8	14.65	77.9	13.92	278	......	......
411	Chris. Miller....	"	20.6	17.10	83.0	16.25	325	......	......
412	Wm. Craigg	"	18.3	14.35	78.4	13.63	273	....	......
413	A. H. Wilcox....	"	18.1	16.80	92.8	15.96	319	......	.....
414	M. H. Wilcox .	"	20.8	17.00	81.7	16.15	323	....	.....
		Tioga.							
415	J. P. Forman ...	Nichols...	22.6	19.75	82.4	18.76	375	....	......
416	Jerome Oakes..	Ketchumv	21.3	17.70	83.1.	16.82	336	......	......
		Tompkins							
417	E. Lobdell......	Freeville .	19.3	15.65	81.1	14.87	297	12.76	3790
418	T. H. King.....	Trum'sbg.	23.6	20.68	87.6	19.65	393	15.68	6162
419	Jas. Heffron	Slaterville	21.9	18.20	83.1	17.29	346	20.69	......
420	W. H. Burnham,	Groton ...	21.3	18.00	84.5	17.10	342	18.95	7076
421	G. C. Gooding..	" ...	20.2	16.35	80.9	15.53	311	......	5893
422	F. D. Sincebaugh	Ithaca....	22.1	19.50	88.2	18.53	371	......	......
423	C. C. Fitch.....	W. Groton	22.1	18.05	81.7	17.15	343	......	......
424	H. W. Preswick.	Forest H.	17.4	13.50	77.6	12.83	257	......	......

Character of soil				Character of cultivation.		Dates of			Distance Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches	No cultivations.	Planting	Thinning.	Harvesting.	Between rows	Between beets in rows	Harvested	In samples analyzed
Clay L.	17	Hay		S. 8	6	M'y 20	Jun. 15	Oct. 18	32	11.0	1.63	1.76
Stony "	15	Corn		" 8	2	Jun. 10	Jul. 11	" 16	18	12.0	.92	.56
Sandy L.												.79
"												95
"												.77
"												1.34
"												1.03
"												1.15
"												.79
"												.77
"												.55
"												.48
"												1.08
"												1.00
"												1.03
"												.86
"												1.34
"												1.08
"												1.15
"												.85
"												.98
"												.84
Loam		Potatoes		S		M'y 20		" 11				.38
		Meadow			3	" 20	Jul. 27	" 19	30			1.46
Muck				"					24	8.0	.73	1.08
Clay L.		Potatoes		"	6	" 28	" 26	Nov 10	28	6.0	.85	.92
												.69
Gravel L		Corn	'96	"		" 8	" 10	Oct. 9	32	7.0	1.46	1.12
Sandy "		Beets		"	5	" 1	" 15	" 13	32	11.0	2.17	2.37
												.46
												.63
Loam									36			1.49

Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns			
					Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons.	Pounds of sugar per acre.
	Wayne.							
425 Porter Butts	Sodus	20.8	16.25	76.3	15.44	309	13.34	4122
426 E. B. Norris	"	19.7	15.50	78.6	14.73	295	10.78	3180
427 W. H Baker	"	18.0	15.00	83.3	14.25	285	14.70	4189
428 W. F. Filkins	"	21.8	18.20	83.5	17.29	346	7.12	2464
429 Warren Nicholas	"	18.4	15.70	85.3	14.92	298	13.55	4038
430 E. W. Danford	"	20.8	17.50	84.1	16.63	333	14.72	4902
431 Jas. Leadley	"	20.0	15.55	77.7	14.77	295	16.12	4755
432 Chas. Hullett	"	20.2	17.15	84.9	16.29	326	6.97	2272
433 Jas. Hanby	"	20.6	16.95	82.3	16.10	322	14.15	4556
434 C. R. Sprang	"	21.5	19.05	88.6	18.10	362	8.71	3153
435 J. T. Piersall	"	19.5	16.25	83.3	15.44	309	7.01	2166
436 Martin Percy	"	20.9	17.25	82.5	16.39	327	7.84	2564
437 Willis Dufloo	"	19.3	15.55	80.5	14.77	295	7.40	2183
438 Peter DeMay	"	18.2	14.70	80.7	13.97	279	24.83	6928
439 Lawson Arms	"	20.4	17.00	84.7	16.15	323	11.10	3585
440 A. J. Folland	"	20.9	17.85	85.4	16.96	339	12.63	4282
441 F. Blanchard	"	18.1	13.50	74.6	12.83	257	19.00	4883
442 R. Robinson	"	20.4	16.40	80.4	15.58	312	......	......
443 Frank Butts	Joy	18.80	15.05	80.0	14.30	286	10.45	2989
444 A. Hollebrant	"	17.70	14.00	79.1	13.30	266	9.58	2548
445 Jacob Shuler	Lyons	20.65	17.98	87.0	17.08	342	9.15	3129
446 L. H. Clark	Sodus	20.6	17.35	84.2	16.48	330	......	......
447 H. G. Hotchkin	Lyons	19.5	16.70	85.6	15.87	317	20.04	6353
448 E. P. &C. S. Rogers	"	21.2	17.20	81.1	16.34	327	......	......
449 J. H. Albright	Ontario	20.7	18.95	91.1	18.00	360	......	......
450 W. D. Post	Wolcott	23.4	20.70	88.4	19.67	393	......	......
451 E. B. Pindar	Westbury	21.7	18.65	85.9	17.72	354	10.89	3855

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets, without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows..	Between beets in rows......	Harvested.....	In samples analyzed ....
Clay L...	60	Roots	'97	S., 10..	6	M'y 19	Jul. 9	Oct. 5	28	10.	1.22	1.58
" "...	60	Mangolds .	'97	" 8..	9	" 25	Jun. 25	" 5	32	10.5	1.18	1.35
Sandy "...	70	Potatoes......	.....	" 4..	..	" 20	" 18	" 9	24	6.0	.70	1.03
Clay "...	40	Hay.........	.....	F., 8..	4	Jun. 1	Jul. 2	" 5	30	5.0	.43	1.12
Gravel "...	65	Garden	.....	" 5..	4	M'y 20	Jun. 21	" 8	18	8.0	.65	1.06
Clay "...	70	"	.....	S., 7..	4	" 20	" 18	" 8	36	5.0	.95	1.21
Sandy "...	60	" ...	'97	" 6..	5	Jun. 5	Jul. 1	" 7	20	10.0	1.05	.68
" "...	70	"	'97	" 6..	7	M'y 15	" 10	" 7	36	6.5	.55	.75
" "...	60	Buckwheat		" 6..	3	Jun. 10	......	" 7	24	5.0	.67	.60
Clay "...	65	Grass	'97	" 7	3	M'y 22	Jun. 20	" 8	24	8.0	.54	.83
" "...	6	....	'97	" 5..	6	Jun. 14	Jul. 12	" 8	20	7.5	.37	.59
Sandy "...	65	Oats, peas.	'96	" 6..	6	M'y 18	Jun. 14	" 6	28	6.0	.44	.96
Clay "...	70	Corn	'96	" 7..	5	" 7	" 23	" 7	30	10.0	.70	1.02
" "...	60	Potatoes ..	'96	" 8..	3	Jun. 1	" 28	" 7	20	6.5	1.06	1.65
Sandy "...	70	Corn	....	" 8..	3	" 15	Jul. 12	" 6	24	12.0	1.04	1.20
Gravel "...	70	....	'96	" 6..	5	M'y 20	Jun. 20	" 7	28	11.0	1.29	1.00
Sandy "...	60	Pigyard		" 8..	3	" 28	......	" 8	16	10.0	.92	1.13
.....	.....	.....	.....	....	..	" 25	......	" 23	..	.....	....	1.33
Sandy "...	60	Grass	'97	" 5..	6	" 25	" 25	"	30	12.0	1.20	1.32
" "...	40	Potatoes...	'96	" 8..	5	" 25	" 25	"	28	11.0	1.14	1.43
Clay "...	..	Cabbage...	'96	" 6	2	" 15	" 15	" 4	24	12.5	.90	.97
....		....	..	....		" 15	Jul. 3	" 23	20	5.0	.52	.77
Clay		....	...	....	..	Apr 30	Jun. 10	" 21	32	12.0	2.42	2.00
Sandy L...	..	....	...	......	..	M'y 15	......	" 25	32	.....	....	1.35
....		....	..	......	6	......	......	......	..	....	...	...
Sandy L.	40	....	...	" 7..	6	......	......	" 8	28	....	.62	.94
Clay "...		....	....	....	..	M'y 15	" 15	" 1	18	7.0	.42	.57

						Beets without crowns.			
	Name.	County.	Brix° or per ct. solids in the juice.	Per ct. sugar in the juice.	Purity. Per cent.	Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets. Tons	Pounds of sugar per acre.
		Yates.							
452	Ed. C. Wilkinson	Penn Yan	23.6	20.00	84.6	19.00	380	22.88	8694
453	"	"	21 2	18.65	88.0	17.72	354	22.88	8694
454	"	"	21.4	18.65	87.1	17.72	354	22.88	8694
455	"	"	20.8	19.40	93.2	18.43	369	22.88	8694
456	"	"	21.7	19.70	90.7	18.72	374	22.88	8694
457	"	"	23.6	21.30	90.3	20.24	405	22.88	8391
458	"	"	22.5	20.50	91.1	19.48	390	22.88	8694
459	"	"	20.1	17.00	84.6	16.15	323	22.88	8694
	The following six analyses are on a								
		Monroe.							
460	M. H. Cusick...	Clarkson .	19.7	15.85	80.5	15.06	301	13.29	4000
461	Jas. Wilson.....	Churchv	15.4	12.10	78 6	11.50	230	20.69	4759
		Erie.							
462	Fred Geiger....	N. Collins.	13.8	10 75	77.9	10.21	204	26.00	5304
463	" "	"	11.9	8.60	71.4	8.17	163	26 00	4238
		Orleans.							
464	S. C. Bowen ...	Medina ..	12.1	8.50	70.3	8.08	162	......	......
	The following twenty-four analyses are on a								
		Chau'qua.							
465	R. L. Newton...	Irving....	19.9	17.45	87.7	16.58	332	28.00	9296
466	"	"	19.9	16.70	83.9	15.87	317	33.10	10493
467	W. T. Christy..	Silver C.,	19.5	16.40	84.0	15.58	312	23.52	7338
468	B. L. Baker.....	Irving....	16.3	12.50	76.7	11.88	238	35.00	8330
469	"	"	16.5	11.55	70.0	10.97	219	35.00	7665
470	John Rakes.....	"	22.8	20.00	87.7	19.00	380	28.00	10640
471	"	"	22.8	20.10	88.2	19.10	382	28.00	10696
472	Insley Mott ...	"	15.6	11.45	73.4	10.88	218	26.00	5668
473	"	" ...	21.0	18.45	87.9	17.53	351	......	......
474	Chas. Crawford.	"	22.4	20.10	89.7	19.10	382	16.00	6112
		Wayne.							
475	H. G. Hotchkiss.	Lyons ..	17.9	14.35	80.2	13.63	273	22.87	6244
476	Jas. Gould.....	"	20.2	17.55	86.9	16.67	333	......	......

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg. wt. of beets without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows..	Between beets in rows.......	Harvested.......	In samples analyzed.....
Gravel L...				S.....	6	M'y 27	July..	Nov 27	32			1.07
" "...				".....	"	"	"	"	32			.76
				".....	"	"	"	"	32			1.15
" "...				".....	"	"	"	"	32			1.46
" "...				".....	"	"	"	"	32			1.11
" "...				".....	"	"	"	"	32			1.33
" "...				".....	"	"	"	"	32			1.22
" "...				".....	"	"	"	"	32			1.46
variety of sugar beet known " Rose Imperial."												
Clay L..	65	Beets......	'96	S., 8	7	M'y 8	M'y 24	Oct. 13	20	10.0	.85	1.05
" "...				S., 6	8	M'y 16	Jun. 20	" 18	36	5.5	1.36	1.05
" "...						Jun. 1		" 13				1.29
" "...						" 1		" 13				1.59
												1.76
variety of sugar beet known as " Vilmorin."												
												1.01
Bot'm L...				S.....	4	M'y 30	Jun. 20	Oct. 6	18	8.0	1.55	1.07
Gravel "...	35			" 8...	5	" 8	M'y 20	Nov. 6	18	6.5	.90	1.02
Bot'm "...	30			"	4	" 17	Jun. 10	Oct 13				1.35
" "...				"	2	" 17	" 10	" 13				.89
Black "...						" 8	" 20	" 13				.82
" "...						" 8	" 20	" 13				.86
Bot'm "...						Jun. 2		" 13				.92
												.89
" "...						M'y 28	' 25	" 13				.66
Clay						Apr 30	" 10	" 21	32	10.0	2.28	2.03
												1.42

	Name.	County.	Brix° or per ct. solids in the juice	Per ct. sugar in the juice.	Purity. Per cent.	Beets without crowns. Per ct. sugar in the beet.	Pounds of sugar per ton beets.	Yield per acre of beets Tons.	Pounds of sugar per acre.
		Erie.							
477	E. G. Fenton...	Fenton. ..	16.8	13.20	78.6	12.54	251	34.74	8720
478	"	"	17.5	14.75	85.3	14.01	280	......	......
479	"	"	17.0	13.95	82.1	13.25	265	......	......
480	Chas. Sager......	"	21.2	18.65	88.0	17.72	354	......	......
481	C. Oldenburg...	"	23.3	21.15	90.7	20.09	402	......	......
482	W. C. Sherman .	"	17.9	14.40	80.4	13.68	274	18.00	4932
483	A. B. Fenton....	Buffalo. ..	23.6	20.00	84.7	19.00	380	......	.....
484	"	"	21.0	15.65	74.5	14.87	297	......	......
		Ontario.							
485	C. Coolidge	Phelps ...	19.4	15.25	78.6	14.49	290	......	......
		Oneida.							*
486	J. Mason........	Clinton...	18.1	13.35	73.7	12.68	254	30.00	7620
487	"	"	18.6	14.80	79.6	14.06	281	30.00	8430
		Chau'qua.							
488	F. Dean	SilverCr'k	20.3	17.25	85.0	16.39	328	......	......
		Onondaga							
489	L. L. Cramer ...	Baldwinsv	19.2	14.85	77.3	14.11	282	......	......
		Monroe.							
490	M. H. Cusick...	Clarkson .	23.9	19.20	80.3	18.24	365	15.03	5486
		Erie.							
491	E. G. Fenton....	Fenton ...	18.3	14.70	80.3	13.97	279	......	......
492	"	"	17.9	13.90	77.6	13.21	265	27.88	7388
		Wayne.							
493	H. G. Hotchkiss	Lyons....	18.4	14.95	81.3	14.20	284	22.65	6433
494	Data missing...	....	19.1	16.15	84.6	15.34	307	......	.....
495	....	....	19.3	15.75	81.6	14.96	299	......	......
496	....	....	21.5	19 00	88.4	18.05	361	......	......
497	....	....	22.2	20.50	92.3	19.48	......	......	......
498	....	....	20.3	16.70	82.3	15.57	317	......	......

The following five analyses are on a

Character of soil.				Character of cultivation.		Dates of			Distance. Inches.		Avg wt. of beets, without crowns. Lbs.	
Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows..	Between beets in rows.......	Harvested......	In samples analyzed......
Light L...	35	Strawberr's	'96	S., 8..	5	Apr 27	M'y 24	Sep 26	18	8.0	1.61	2.62
... .	..	....	....	....	..	......	......	......	..	......	....	3.63
....	..	....	....	....	..	......	......	......	..	......	....	4.43
Stiff L ...	..	....	....	....	..	M'y 27	Jun. 15	" 16	..	......	....	1.08
"	..	....	....	....	..	Jun. 15	" 30	" 22	..	......	....	1.25
Gravel L ..	..	....	....	....	..	M'y 25	" 25	" 13	..	......	....	1.76
Lowland...	20	....	....	....	..	Jun. 1	" 20	Nov. 1	..	......	....	.59
....	..	....	....	....	..	......	......	....	..	......	....	2.85
Loam	..	Hay.......	'96	"	5	M'y 19	" 12	Oct. 14	36	.....	....	1.32
Bottom L..	..	....	....	....	..	M'y 30	Jun. 15	" 13	..	... .	....	.82
"	..	....	..	....	..	" 20	" 15	" 13	..	.....	....	1.23
....	..	....	....	....	..	" 20	......	......	..	.....	....	.58

variety of sugar beet known as "French White."

Kind of soil.	Cultivation. Yrs.	Previous crop.	Barn manures last applied in.	When plowed and depth. Inches.	No. cultivations.	Planting.	Thinning.	Harvesting.	Between rows..	Between beets in rows.......	Harvested......	In samples analyzed......
Sandy L...	..	....	...	......	..	M'y 5	M'y 24	Nov. 9	16	.....	4.00	1.00
Clay " ...	65	Beets......	'95	S.....	7	" 8	" 24	Oct. 13	20	9.5	.91	.81
....	..	....	....	....	..	......	......	......	..	....	...	4.90
Sandy " ...	..	....		" ...	7	" 15	Jun. 27	" 21	30	11.0	2.91	3.09
Clay ".....	..	....	....	....	..	Apr 30	Jun. 10	" 21	32	10.5	2.48	2.22
....	..	....	....	"	6	M'y 27	July..	Nov 27	32	.....	....	1.20
....	..	....	....	"	"	"	"	"	32	.....	....	2.14
....	..	....	...	"	"	"	"	"	32	.....	....	1.53
....	..	....	....	"	"	"	"	"	32	.....	....	1.10
....	..	....	....	"	"	"	"	"	32	.....	....	1.68

SAMPLES OF MANGOLD WURZEL ANALYZED AS FOLLOWS:

Date harvested.	Weight of beet without crown. Lbs.	Brix° or per cent solids in the juice.	Per cent sugar in the juice.	Purity. Per cent.
Sept. 25	4.05	7.5	3.50	46.7
“ 25	4.05	10.4	6.70	64.4
“ 29	3.05	10.4	7.20	69.2
“ 29	2.49	9.0	4.50	50.0
Oct. 6	1.96	13.8	10.45	75.7
“ 20	2.05	11.1	5.65	50.9
“ 20	1.57	13.2	7.90	59.8
Nov. 6	1.49	9.9	5.50	55.6
Samples of red turnip garden beet analyzed as follows:				
Oct. 6	1.39	14.0	11.30	80.7
“ 6	3.13	12.8	9.80	76.6

From the preceding tables the following general averages are drawn:

A comparison of the beets grown on sandy loam with those from clay loam shows only a slight dfference in favor of the clay.

	Per cent sugar in juice.	Per cent purity.
Quality of beets grown on *sandy loam*: 112 analyses, averaged	16.66	83.1
“ “ “ *clay* “ 109 “ “	17.29	83.8

The distance between rows did not seem to effect materially the quality of the beets.

Quality of beets grown in rows 30 inches or more apart: 108 analyses, averaged	16.71	83.0
Quality of beets grown in rows less than 20 inches apart: 115 analyses, averaged	16.96	83.3

The statement that barn manure should be applied to the preceding crop and not directly to the beets as effecting the quality is substantiated in the following table:

	No cases.	Per cent sugar in juice.	Per cent purity.
Manure applied in 1896	45	17.37	83.96
“ “ 1897	59	16.62	82.94

The following cases have been selected showing what influence, if any, is exerted by the preceding crop:

EFFECTS OF PREVIOUS CROPS.

Previous Crop	No. Cases.	Per cent sugar in juice.	Per cent purity.
Hay	24	17.47	84.5
Potatoes	28	16.86	83.1
Corn	26	17.20	84.9
Cabbage	12	17.56	84.9
Grain crop not tilled	11	17.94	85.3

PER CENT OF SUGAR AND PURITY OF THE JUICE INFLUENCED BY SIZE OF BEETS.

	No. of samples analyzed	Per cent sugar in juice.	Per cent purity of juice..
		Average.	Average
Beets weighing less than .50 lbs.	7	18.46	85.4
" " from .50 lbs. to .75 lbs.	48	17.91	85.5
" " " .75 lbs. to 1.00 lbs.	95	17.37	83.9
" " " 1.00 lbs. to 1.25 lbs.	123	17.17	84.3
" " " 1.25 lbs. to 1.50 lbs.	95	16.42	82.6
" " " 1.50 lbs. to 1.75 lbs.	47	16.09	81.8
" " " 1.75 lbs. to 2.0 lbs.	15	15.33	81.4
" " " 2.00 lbs. to 3.00 lbs.	22	15.45	81.0
" " " 3.00 lbs. to 4.00 lbs.	4	14.99	84.6
" " " 4.00 lbs. to 5.00 lbs.	3	13.47	78.6
" " " 5.00 lbs. and over	1	13.75	78.1

In general the smaller the beet when mature the higher the per cent of sugar and purity; and the larger the beet when mature the lower the per cent of sugar and purity.

Sugar beets may be so small that it would not pay to grow and harvest them. They may also be grown too large and coarse to be profitably used in sugar making. Between these two extremes there is a size of beet that can be most profitably grown—this ranges from 1¼ to 2 pounds.

Per Cent of Sugar and Purity of Beet Crowns.

It is generally supposed that the per cents of sugar and purity of beet crowns are much lower than in the beet proper. In several cases beets were taken and the crowns removed, and each analyzed separately with the following results.

CROWNS AND CROWNLESS BEETS COMPARED.

	Per cent sugar in juice.	Per cent purity in juice.
Crown	12.00	73.6
Crownless beet	13.45	79.1
Crown	10.20	65.8
Crownless beet	12.50	73.5
Crown	13.30	83.1
Crownless beet	16.05	85.4
Crown	12.40	74.2
Crownless beet	13.95	79.3
Crown	12.25	77.5
Crownless beet	14.70	87.0
Crown	10.40	65.8
Crownless beet	13.35	79.9
Crown	11.45	71.5
Crownless beet	13.35	79.0

How Much Plant Food does the Sugar Beet Plant Consume?

On Nov. 6, '97, composite samples of three freshly pulled plants were made as follows: The leaves were put in one lot, the crowns in a second lot, the crownless beets in a third lot and the moisture determined in each with the following results:

	When pulled green.	Dry.	Per cent dry matter.
Weight of leaves (from three plants)	237.8 grams	53.0 grams	22.29
" crowns " "	279.7 "	56.7 "	20.27
" crownless beets " "	902.0 "	183.5 "	20.34

ANALYSES OF THE DRY OR WATER-FREE SAMPLES.

	Nitrogen. Per cent. N.	Potash. Per cent. K_2O.	Phosphoric acid. Per cent. P_2O_5.	Calcium oxide. Per cent, CaO.	Ash. Per cent.
Leaves	2.89	4.88	0.51	1.86	19.31
Crowns	2.13	2.21	0.59	0.27	6.68
Crownless beets.	1.38	1.77	0.55	0.15	4.14

These analyses when calculated to the *fresh or green samples* at time of pulling are as follows:

	Nitrogen. Per cent. N.	Potash. Per cent. K_2O.	Phosphoric acid. Per cent. P_2O_5.	Calcium oxide. Per cent. CaO.	Ash. Per cent.
Leaves	0.64	1.09	0.114	0.41	4.30
Crowns.........	0.43	0.45	0.120	0.05	1.35
Crownless beets.	0.28	0.36	0.112	0.03	0.84

Any one of these percentages whem multiplied by 20 will give the number of pounds of that substance in a ton of the material taken. Thus, green leaves analyzed 0.64 per cent nitrogen: then 20×0.64=12.8 pounds of nitrogen in one ton of green or fresh leaves. The amount of the other substances in a ton may be obtained from the analyses in a similar manner.

In order to approach the question of how much plant food a crop of sugar beets takes up per acre, it is of great importance to know the relative proportion of *leaves*, *crowns* and *crownless beets* by weight in the crop grown.

The following table gives the weights of these parts in twenty-four samples weighed at time of harvesting:

PROPORTION OF LEAVES, CROWNS AND CROWNLESS BEETS.

Weight when harvested.			In 100 parts by weight of the entire beet plant when harvested.		
Beet without crown in pounds.	Crown in pounds.	Leaves in pounds.	Parts in beet without crown.	Parts in crown.	Parts in leaves.
0.72	0.30	0.43	49.66	20.69	29.65
0.83	0.33	0.42	52.53	20.89	26.58
0.85	0.26	0.32	59.44	18.18	22.38
0.88	0.21	0.35	61.11	14.59	24.30
1 02	0.39	0.22	62.58	23.93	13.49
1.30	0.36	0.38	63.73	17.64	18.63
1.09	0.23	0.51	59.56	12.57	27.87
1.17	0.38	0.22	66.10	21.47	12.43
0.92	0.53	1.05	36.80	21.20	42.00
1.32	0.39	1.04	48.00	14.18	37.82
1.35	0.33	0.71	56.49	13.81	29.70
0.79	0.23	0.69	46.20	13.45	40.35
0.79	0.29	0.41	53.02	19.46	27.52
2.12	0.32	0.45	73.36	11.08	15.56
0.84	0.27	0.61	48.84	15.70	35.46
1.52	0.34	0.25	72.04	16.11	11.85
1.14	0.32	0.25	66.67	18.71	14.62
1.01	0.36	0.86	45.29	16.14	38.57
1.10	0.39	0.30	61.45	21.79	16.76
1.06	0.35	0.45	56.68	18.72	24.60
0.93	0.39	0.42	53.45	22.41	24.14
1.39	0.34	0.42	64.65	15.82	19.53
0.86	0.28	0.37	56.96	18.54	24.50
0.95	0.24	0.41	59.38	15.00	25.62
Total weights 25.95	7.83	11.55	57.24	17.28	25.48
Average weight 1.08	0.33	0.48	Average parts per 100.		

Individual cases in the foregoing table differ greatly from each other, but it may be assumed that the average of the 24 cases will be very nearly correct.

In round numbers, then, in 100 parts of the whole plant when harvested, *57 parts* are beet without crown, *17 parts* crown and *26 parts* leaves, so that in one ton (2000 pounds) of the whole beet plant there are in :

Fresh leaves	520 pounds.
Fresh crowns	340 pounds.
Fresh crownless beets	1140 pounds.
	2000

This ton of plants will contain the following amounts of plant food.

	Pounds nitrogen.	Pounds potash.	Pounds phosphoric acid.
Fresh leaves. 520 lbs. contains	3.33	5.67	0.59
Crowns, 340 lbs. contains	1.46	1.53	0.41
Fresh crownless beets, 1140 lbs. contains	3.19	4.10	1.28
Total, 2000 lbs...........	7.98	11.30	2.28

Generally the leaves are left on the ground and only the beet and crowns taken from the field; this being so it is necessary to know *what proportion of the beet is crown*, and so in several hundred cases beets were weighed before and after removing the crowns with the following results.

The average of 454 cases weighed, showed that in every 100 parts of the whole beet (leaves not included), 80.86 parts were crownless beets and 19.14 parts were crowns; or in round numbers 81 parts were crownless beets and 19 parts crowns.

Therefore in one ton of beets harvested, leaves not taken into account, there are in:

Fresh crownless beets.............................	1620 pounds.
Fresh crowns....................................	380 pounds.
	2000

This ton contains the following amounts of plant food:

	Pounds nitrogen.	Pounds potash.	Pounds phosphoric acid.
Crownless beets, 1620 lbs. contains......	4.54	5.83	1.81
Crowns, 380 lbs. contains....	1.63	1.71	0.46
Total, 2000 lbs contains....	6.17	7.54	2.27

From the preceding analyses it may be said that, when freshly harvested and not withered :

	Nitrogen.	Potash.	Phosphoric acid.	Water
	Pounds	*Pounds*	*Pounds*	*Pounds.*
1 ton of *whole plants* (roots, crowns and leaves) contains	7.98	11.30	2.28	1583.3
1 ton of *beets* (roots and crowns) contains	6.17	7.54	2.27	1593.5
1 ton of *leaves* contains	12.80	21.80	2.28	1554.2
1 ton of *crowns* contains	8.60	9.00	2.40	1594.6
1 ton of *crownless beets* contains	5.60	7.20	2.24	1593.2
Factory By-products.				
1 ton of extracted cossettes*, or beet pulp	1.82	1.72	.32	1828.0
1 ton of molasses*	21.40	65.20	.34	832.0
1 ton of lime-cake*	2.48	3.05	8.47	871.2

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* The extracted cossettes, molasses and lime-cake were received from the Rome Beet Sugar Factory. The extracted cossettes, or beet pulp, is a by-product of the diffusion tanks. The molasses is a by-product of the centrifugal machines. The lime-cake is a by-product of the carbonatation tanks.

The lime-cake contained 25.96 per cent of lime (CaO).

NOTE.—*Pounds per ton* of any of the above plant-foods divided by 20 will give the *per cent* of that plant-food in the material,—thus: 7.98 lbs. nitrogen ÷ 20 =.399 per cent of nitrogen in *whole plant.*

New York State Weather-Conditions, from April 1st to October 31, 1897.

It may be said that the general average, or *normal* temperature for corresponding months does not vary much from year to year; and that the temperature conditions in New York State are good for the growth and development of *sugar* in the sugar beet plant. The average amount of sunshine also is amply sufficient for the proper growth and development of the sugar beet.

The *rainfall* or *moisture* condition is of the greatest importance. The total rainfall during any one year is ample for growing sugar beets, provided it has been sufficiently distributed through the growing season.

In brief* we may say that during:

APRIL.—There was a slight increase over the normal rainfall for most of the State. Temperature 1.3 degrees above the normal.

MAY.—Decidedly more than the normal rainfall. Temperature averaged 0.8 degrees below the normal.

JUNE.—Very nearly normal rainfall. Temperature 4.1 degrees below the normal.

JULY.—Extremely wet, having 3.26 inches more than normal rainfall. Temperature 2.4 degrees above the normal.

AUGUST.—Slightly below the normal rainfall. Temperature averaged 1.7 degrees below normal.

SEPTEMBER.—Dry, 1.37 inches below the normal rainfall. Temperature 0.1 degree below normal.

OCTOBER.—Exceedingly dry, 2.45 inches below the normal rainfall. Temperature 2.8 degrees above the normal. The New York State Weather Bureau Report for October, 1897, page 3, says: "The rainfall over the greater part of New York ranks among the least recorded for October, and the average for the State was less than for any preceding month since the establishment of this Bureau in 1889. A severe drouth prevailed in the western and central sections, and portions of the Hudson and Champlain Valleys, groundwater being reported as lower than for many years past. Winter wheat and pastures suffered considerably, and in many cases the ground was too dry for plowing."

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*Condensed from the New York State Weather Bureau Report, Central Office at Cornell University. Professor E. A. Fuertes, Director, Ithaca, N. Y.

The following table gives the rainfall for each month, April to October inclusive, in those counties that have grown sugar beets and have had analyses made at the Cornell Experiment Station. If there are two or more *Signal Stations* in a county reporting rainfall, then the average rainfall of the several stations is given.

PRECIPITATION IN INCHES.

	COUNTY.	April.	May.	June.	July.	Aug.	Sept.	Oct.
1	Albany	3.12	4.69	4.45	6.67	4.43	1.87	1.01
2	Broome	2.16	4.45	3.35	2.42	1.61	3.30	0.74
3	Cattaraugus	2.08	3.62	2.71	6.83	....	1.25	0.56
4	Cayuga	2.34	2.92	3.93	4.11	2.26	3.27	1.31
5	Chautauqua	3.29	3.65	2.32	6.79	3.55	0.81	1.56
6	Erie	2.18	2.72	1.87	6.16	1.93	0.47	1.07
7	Genesee*	1.87	2.45	1.85	4.54	1.49	0.84	1.04
8	Herkimer	3.99	4.73	5.47	5.00	2.98	1.88	1.38
9	Jefferson	....	....	2.05	8.22	3.54	0.78	0.42
10	Livingston	1.66	2.15	2.03	3.14	0.55	1.21	0.66
11	Monroe	2.10	1.94	2.65	6.10	1.46	0.77	0.92
12	Montgomery	1.93	4.10	4.91	5.58	3.13	1.89	0.84
13	Niagara	2.52	2.87	1.79	5.68	1.54	0.93	1.06
14	Oneida	3.36	4.12	4.87	4.92	2.71	2.30	0.38
15	Onondaga	2.67	2.77	3.19	5.44	2.36	1.97	0.80
16	Orleans	2.62	2.77	1.77	5.07	2.08	0.38	1.01
17	Oswego	2.19	2.60	3.67	3.98	2.42	1.09	0.57
18	Saratoga	3.68	6.35	6.63	8.83	4.70	1.65	1.45
19	Schuyler	2.64	3.00	3.00	3.27	2.19	2.66	0.71
20	Seneca	2.53	4.80	2.71	4.14	0.78	3.95	1.21
21	Steuben	2.55	3.54	2.56	6.30	2.49	2.51	0.96
22	Tioga	2.95	3.98	3.59	4.32	3.19	4.05	0.56
23	Tompkins	2.65	3.90	3.65	3.78	2.48	4.59	0.94
24	Wayne	2.33	1.98	3.85	4.44	1.19	1.15	0.62
25	Yates	....	....	....	....	1.28	1.90	0.62

*No report sent in, so the rainfall given is the average for Signal Stations at Ridgeway Avon and Akron.

THE FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION TO THOSE WHO MAY DESIRE THEM.

38 Native Plums and Cherries, 73 pp.
39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf-Bug, 35 pp.
59 Does Mulching Retard Maturity of Fruit, 14 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
67 Some Recent Chinese Vegetables, 27 pp.
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80 The Quince in Western N. Y., 27 pp.
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138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report upon Japanese Plums, 15 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a cause of Death Among Swill-Fed Pigs, 12 pp.
142 The Codling-Moth, 69 pp.
143 Sugar Beet Investigations, 88 pp.

Bulletin 144. **January, 1898.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

Entomological and Horticultural Divisions.

NOTES ON SPRAYING

—AND—

ON THE SAN JOSÉ SCALE.

By H. P. GOULD.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N Y.
1898.

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In pursuance of the provisions of Chapter 128 of the Laws of 1897, several persons were appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work required.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.

CORNELL UNIVERSITY, ITHACA, N. Y., January 28, 1898.
THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: This bulletin is submitted for publication under Chap. 128 of the Laws of 1897.

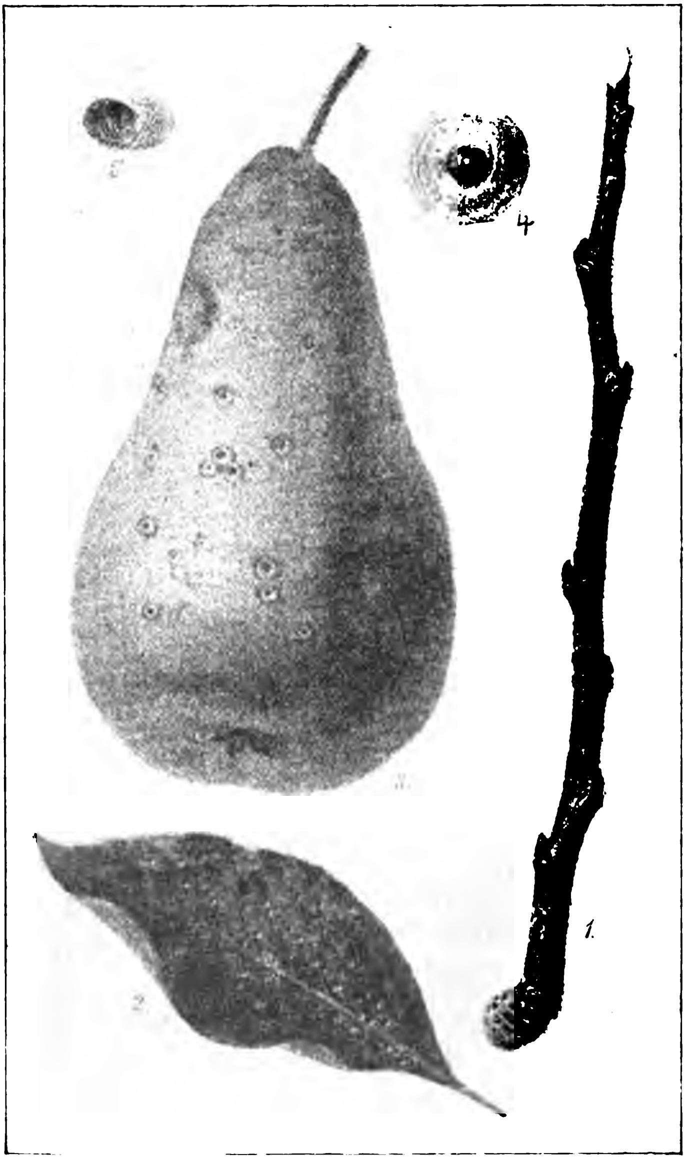
The following notes, which have been prepared by Mr. H. P. Gould, under the direction of Mr. M. V. Slingerland and Professor L. H. Bailey, embody some additional information on Spraying and supplements the information contained in Bulletins Nos. 86, 101 and 114, together with investigations looking toward the control of the San José scale which has appeared in several sections of the State.

Perhaps no subject connected with fruit-growing requires more careful study and investigation at the present time than this new pest, which has already secured a firm foothold in many localities. Unless some means can be found for arresting its spread and of eradicating it where it has already appeared, the great fruit industry of New York, which now brings many millions of income to the farmers, will have to be largely abandoned.

I am inclined to believe that if the orchardists are kept promptly informed of the spread of this scale and can be furnished with information as to the best means of destroying it, most of the young and thrifty plantations may be saved, if not entirely freed from this most dangerous of all pests which has yet appeared in the orchards.

Very respectfully yours,

I. P. ROBERTS,
Director.



THE SAN JOSÉ SCALE.

1, *Infested branch*; 2, *infested leaf*; 3, *pear, bearing a few of the scales*; 4, *female scale—enlarged*; 5, *male scale—enlarged.*
(*Adopted from report of W. G. Klee, 3d Rept., Cal. Bd. Hort.*)

SUGGESTIONS ON SPRAYING.

The expediency of spraying plants has already passed the experimental stage. The fact of its value has been too thoroughly and too often demonstrated to permit any doubts concerning the advisability of such an operation; yet there is much to be learned about spraying. The fact, however, that it pays to spray, does not seem to be so fully appreciated by fruit growers and others as it ought to be; so the first part of this bulletin is intended not so much for the purpose of recording new facts as to emphasize and reiterate a few fundamental principles upon which successful spraying depends.

During the first few years after spraying began to receive attention in this country, the efforts directed thereto resulted in setting forth the fundamentals of the operation, together with extensive trials of apparatus and materials. The experience of the past two years or so, while fruitful of much that is valuable, has not propounded new principles and perhaps fewer spraying materials have been introduced and less apparatus invented than for some years previous; but much apparatus already on the markets has been improved and perfected so that advancement in this direction has been considerable. It would seem now that most of the progress in spraying must be along the lines of improved materials and perfected apparatus.

Some remarks on spraying materials.—In regard to new insecticides and fungicides a word of caution is not out of place. Many of these materials are recommended for almost every disease to which plants are subject. By this we do not wish to be understood to say that the compounds, such as those in question, are necessarily worthless; on the other hand many of them have a place, and in that place they are good, yet the sweeping recommendations of many of them are misleading.

We are frequently asked concerning substitutes for Paris green.

Arsenite of lime is doubtless one of the cheapest and safest compounds which can readily be obtained. The basis of this insecticide is white arsenic, or "arsenic" as it is more commonly called. In the *Michigan Farmer* of 13 Feb. 1897, Dr. R. C. Kedzie, of the Michigan Agricultural College, gives the following method of preparing it, which may well be termed the "Kedzie mixture." "Dissolve the arsenic by boiling with carbonate of soda, and thus insure complete solution; which solution can be kept ready to make a spraying solution when wanted." Then more specific directions follow, which are, "To make material for 800 gallons of spraying mixture, boil two pounds of white arsenic with eight pounds of salsoda (crystals of carbonate of soda, 'washing soda,' found in every grocery and drug shop) in two gallons of water. Boil these materials in any iron pot not used for other purposes. Boil for fifteen minutes, or till the arsenic dissolves, leaving only a small muddy sediment. Put this solution into a two-gallon jug and label 'Poison—stock material for spraying mixture.'"

"The spraying mixture can be prepared whenever required, and in the quantity needed at the time, by slaking two pounds of lime, adding this to forty gallons of water; pour into this a pint of the stock arsenic solution. Mix by stirring thoroughly, and the spraying mixture is ready for use. The arsenic in this mixture is equivalent to four ounces of Paris green."

In other words, the stock solution may be made by boiling together white arsenic and salsoda at the rate of one pound of the former to four of the latter. This will keep indefinitely in a closed vessel and as it is extremely poisonous it should be carefully taken care of. In applying this stock solution, use two pounds of fresh lime for every pint of the solution. One pint is sufficient to put into a barrel of water.

The materials for this poison cost about 3¼ cents a barrel, making a very cheap and effective poison.

We do not know that this substitute for Paris green has been tried with Bordeaux mixture, but in answer to a question on this point, Dr. Kedzie replied that he saw no objection to the two mixtures being used together.

Our observations upon the effectiveness of this mixture have been confined to its action on potato bugs and here it has proved a very satisfactory substitute for Paris green. It has several advantages over Paris green, chief of which are its cheapness and uniformity of strength.

Since the arsenic, in the form in which it exists in the stock solution, is extremely caustic on the foliage, the addition of a sufficient quantity of lime to neutralize it is very important. Added at the rate given above, however, it seems to be perfectly safe.

As we frequently have inquiries concerning powdered Bordeaux mixture, it seems best to state that, having given it a fair trial, we are not warranted in recommending it for use as a substitute for Bordeaux mixture. The adhesive properties of such material are often poor and, on the whole, they have given very meagre results in comparison with liquid Bordeaux. The results obtained at other experiment stations seem to confirm the results of the work at this station.

Certain modifications of Bordeaux mixture have been made at the New Jersey Agricultural College Experiment Station,* which compare favorably with the usual formula for Bordeaux. In one of these modifications, termed "Soda-Bordeaux," caustic soda was used instead of lime to neutralize the copper sulphate; the quantity of caustic soda recommended is 1.1 pounds for every five pounds of copper sulphate. A second modification substitutes caustic potash for the lime, three pounds of the potash being used to neutralize five pounds of copper sulphate. In this case, however, potash such as is obtained in bulk is referred to and as this contains varying proportions of impurities the quantity (in weight) required to neutralize the copper sulphate will also vary, so in using this formula, as also the one for soda-Bordeaux, it is advisable to test with red litmus paper. Add the caustic soda or potash solution to the copper sulphate until upon inserting into it a little piece of red litmus paper a faint tinge of blue appears; when the blue tinge begins to show, enough has been added. These modified Bordeaux mixtures, in somewhat extended trials, seemed to be nearly if not quite as effective as the common form and in certain cases perhaps present some advantages. They do not clog the nozzle.

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* 9th Ann. Rep. 1896 (Report of Botanist).

Apply the proper remedy at the right time.—One of the essential features of successful spraying, and one often overlooked, is to apply the proper remedy at the right time. To know what to apply and when to apply it is generally not a difficult matter if a few facts be kept in mind. Practically all insect enemies of plants, for which spraying is a specific, may be divided into two classes with respect to their habits of feeding and the remedy to be applied will depend upon these habits. The insects of one class, of which the potato bug and apple tree tent-caterpillar are familiar examples, eat parts of the plant—usually the leaves. The remedy for such pests is to apply a poison to their feeding ground. Paris green is the poison most commonly used in such cases.

The other class of insects comprises those which suck the juices of the plant. The aphides or plant lice which have been so abundant the past season on the growing shoots of apple, plum and cherry trees represent this type; the scale insects, as the San José scale, also belong here. A moment's thought will make it plain that Paris green could in no wise injure an enemy of this sort since it does not get the poison with its food. This type of insect must be destroyed by applying something which will kill it merely by coming in contact with it. Kerosene, usually as an emulsion, is the remedy in most common use. It must be remembered, however, that this will destroy only those insects with which it comes in contact. This, perhaps, will explain at least one of the reasons why *thoroughness* is so essential to success. While kerosene emulsion has been very generally recommended for insects of this type, with the advent of certain pumps which have recently been perfected, this may not be the best way of applying it; with these pumps the kerosene may be so mixed and diluted with water as it is forced through the pump and out of the nozzle that no emulsion is necessary.

It seems almost a waste of time to say that Bordeaux mixture is the great specific for fungous diseases, and that it is not for destroying insects, yet recent experience convinces us that such a statement may well be made with considerable emphasis.*

Two cases where Bordeaux prevents loss by insects.—There are only two cases, so far as we definitely know, wherein Bordeaux is of service in preventing the ravages of insects, and in these instances it cannot properly be called an "insecticide" for it does not kill the insects but simply makes their feeding ground unpleasant. These too cases may be briefly mentioned. It has been repeatedly observed that potatoes well sprayed with Bordeaux are much freer from the attacks of the flea-beetle than unsprayed potatoes are. It was with this fact in mind that the writer, the past spring, sprayed with Bordeaux some cucumber vines which were being destroyed by the striped cucumber beetle. It was with some surprise, considering the persistent habit of these insects, that they were found to have disappeared when the plants were examined a short time after the application was made. Several sprayings served to protect the plants from further injury. This is the result of only one season's experiment; further observations may not confirm this opinion, although similar results have been reported from the New Jersey Agricultural College Experiment Station.† This report had not been seen by the writer when the above experiment was made. The fact ought to be reiterated that the beneficial results of Bordeaux in these cases is simply in making the foliage of the plants an unpleasant place for the insects and as a rule it is of no value as an insecticide.

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* Very often in the spring time persons come to us with this or a similar remark: "My rose bushes are all covered with little white insects. What can I do for them?" We usually say, "Spray them with kerosene emulsion," for that is about the best thing in common use, yet it is somewhat difficult to make and the chances are that persons who ask for this information, rather than bother with making the emulsion, simply look on while the insects continue to eat up their rose bushes and other ornamentals. During the past season we have had various insecticides and fungicides under observation. Among them, was one called "Fir tree oil soap," another "Kill-m-right," both of which have given excellent satisfaction in combating aphis, rose-leaf hopper and other soft bodied insect pests common to the front yard and garden. Each of these is a salve-like material conveniently put up in small tin cans and they are made ready for use simply by dissolving in a little hot water and then diluting to the desired strength. About one ounce to a gallon of water seems sufficient for destroying aphis and other soft-bodied insects.

†9th Ann. Rep. 1896, p. 358.

Thoroughness is most important.—While the application of improper materials and use of right materials at improper times are productive of much dissatisfaction with spraying, we are convinced that carelessness and work indifferently done are the cause of more unsatisfactory results from spraying than almost all other causes combined. Comparatively few people yet know how to spray and do it well, notwithstanding the fact that it is generally not a difficult thing to do. So the one essential to satisfactory results from spraying, as it appeals to us, which needs more emphasis than any other is *thoroughness* in the work. The requisites for such a job of spraying are a tree or plant well pruned, a good pump, a good nozzle, abundance of spraying material (it is not expensive), and with all, a fair degree of patience on the part of those who are doing the work ; then spray the tree until every leaf is moistened,—until the materal begins to drip from the tree. Of course a few other accessories are necessary aside from those mentioned, but they are what anyone attempting to spray would almost of necessity possess.

In these times of low prices, the question of whether to spray or not to spray has often been asked. First-class and fancy fruit of all kinds will usually sell at a profit while inferior grades are a drug on the market at any time. It is a fact of common observation that the finest fruit is that which has been sprayed. Not long ago the writer was comparing two vineyards which were situated side by side and under similar conditions in practically every respect. One vineyard had been thoroughly sprayed and the fruit was perfect, selling at a profit, and the foliage was healthy. The other vineyard had been left unsprayed and scarcely a perfect cluster of fruit could be found and the vines were in as pitiable a condition as the fruit. Such a product could not have sold for enough to pay for picking. This is only one of many instances which might be mentioned as an argument for careful spraying ; and what is true of grapes is often true of other fruits. Again, it sometimes happens that conditions are unfavorable for the development of bugs and fungi and, for a single year, there is very little difference between sprayed and unsprayed fruit. It should be remembered that the effect of spraying is not confined solely to the year in which it is done but among those who have had abundant opportunities for observing it is held, that trees sprayed for a series of years and then left unsprayed for a season, are more vigorous and produce better fruit than trees which have not been sprayed at all.

When to spray and when not to spray.—The time of making the applications varies with the conditions of the season, but for orchard fruits, when treated against the more common insect and fungous foes, we may say in a general way, spray first, just before the fruit buds open; second, just after the blossoms fall; and third, ten days or so after the second spraying. In a dry season, the third application may not be necessary, while in an excessively rainy one more than three may pay.

When to spray cannot be regulated by rule. When not to spray, at least in one particular, can be stated with emphasis. If the spraying solutions contain poisons, as they should at that season of the year, *do not under any conditions spray when the trees are in bloom.* Nothing is accomplished by spraying at this time which cannot be attained either before the blossoms open or after they fall. More than this, irreparable damage is almost sure to follow spraying at this time. Everyone has observed how active the bees are among the blossoms of fruit trees, and on this activity of the bees depends very largely the development of the fruit. As they carry pollen from one blossom to another, they are doing a kindness to the fruit-grower which he little appreciates. If, then, these friends of the orchardist find the blossoms covered with poison, as they will do if the trees are sprayed when in bloom, their death from the effects of the poison is only too sure to follow and with the death of each bee, the fruit grower loses a friend. This loss is not only to the man who grows fruit, but to the bee-keeper as well. It is also a question if the spray may not injure flowers when they are in full bloom.

Conclusion.—All of the foregoing leads to the remark, that the man who sprays or directs the work must think for himself. The various spraying materials can be made by rule, but when it comes to applying them it is a different matter; general directions may be given, but these must be adapted to each case.

A man who has regard for the health of his trees becomes to that extent a doctor; let him take the same care in diagnosing the ailments of his trees, which the physician takes when called to see a patient.

Recapitulation.

1. Many of the recently introduced insecticides and fungicides are no better than some of the older and better known materials, and they are sometimes inferior to them. Page 579.
2. Arsenite of lime prepared according to the directions of Dr. Kedzie seems to be the best substitute for Paris green. Page 580.
3. Powdered Bordeaux mixture has not given good satisfaction with us. Page 581.
4. Certain modifications of Bordeaux as proposed by Halstead may possess some advantages over the common formula for special purposes. Page 581.
5. In spraying for insect foes, the kind of material used must be governed by the feeding habits of insects for which the treatment is made. Page 582.
6. Bordeaux mixture seems to lessen the ravages of the striped cucumber beetle as also the flea-beetle. Page 583.
7. Thoroughness in spraying is one of the most important elements of success and one often disregarded. Page 584.
8. Spray at the proper time. Under no conditions spray with poisons when fruit trees are in full bloom. Page 585.

BRIEF NOTES ON THE SAN JOSÉ SCALE.

The San José scale has already become so widely distributed that its discovery in new and unexpected localities ought not to occasion surprise. And yet, when in the spring of 1897 it was discovered on the horticultural grounds of this station, it was a matter of considerable surprise to those who were directly interested in the case. As soon as the fact of its presence was known, active measures were taken to dispose of the pest and the record of the experience of the past season constitutes the substance of the following notes.

Its occurrence at Cornell.—Whence came the scale to us, no one knows; the time of its coming is equally obscure. It was first discovered during the past spring on dwarf apples trees which had been set some five or six years. When first observed the scales were found in almost innumerable numbers; so thick were they that the bark was completely covered in places. These trees were at once rooted up and burned, a procedure which we have since regretted. An examination of some shrubs of Cornus Baileyi, which were growing close to the apple trees, revealed the presence of the scales in great numbers. The insects were later found upon small shrubs of Pyrus nigra and Pyrus Aria.

The first impression was that it came to us on the dwarf apple trees, but these had been under very close observation for a year or two, and if the scales had been present then, it seems hardly possible that they could have escaped notice. The fact that they were found upon a bush of Cornus Baileyi somewhat removed from the other affected plants seems to give some support to the supposition that the scales came on them and spread to the other species. This seems improbable, however, since all of the plants of cornus came from the wild along the shores of Lake Michigan.

The mystery is the greater when we take note of the fact that all of the affected shrubs and trees have been growing in their present location for five or six years. It is not unlikely that the scale was with us for some years before its discovery and on account of some favorable condition or combination of conditions during the summer of 1896, a rapid multiplication took place, and its presence became conspicuous. See picture on title page.

Treatment.—For certain reasons it was determined to save these shrubs of cornus and pyrus if it were possible, and by the advice of Mr. Slingerland, who, it should be said, has rendered valuable assistance in locating infested plants, noting the effects of sprays, etc., the trunks and larger branches of the shrubs were treated with whale-oil soap, dissolved in water at the rate of two pounds of soap to one gallon of water. This has been much recommended, it being considered the most destructive to the scales of any insecticide which could be used without injury to the host Even this material will injure foliage, so that it must be used when the plants are dormant or else, as in the case in question, applied only to the trunks and larger branches. It should be stated that the infested shrubs under treatment had already leaved out when the scale was discovered.

The effects of the whale-oil soap, thus applied, were all that could be desired. No live scales could be found, after a lapse of several days, where this solution had been applied. A few of the shrubs which had been treated with a solution containing only half as much soap as the above, that is, one pound to a gallon of water, still bore live scales in considerable numbers.

The whale-oil soap was applied about the first of May. Nothing more was done for several weeks, but a careful watch was kept of the condition of the scales, with the intention of treating them with kerosene when the proper time should arrive. In the meantime, numerous experiments were made to determine how strong a mixture of kerosene and water could be safely applied without injury to the foliage. The result of this investigation indicated that a mixture of four parts of water and one of kerosene could be used with little or no danger of burning the foliage.

Accordingly, on June 25, when the condition of the scales seem to indicate that the young insects were about to migrate, the shrubs were thoroughly sprayed with a mixture of kerosene and water in the strength indicated, that is, one volume kerosene to four of water. On July 2, a second application of kerosene and water was made. Treatment was now delayed for a time and on July 23, the shrubs were very carefully examined by Mr. Slingerland and not a single living scale was to be found. We felt encouraged. There seemed to be no need of further attention, so the shrubs were left to themselves; but the end was not yet.

About the first of November, after the leaves had all fallen, the shrubs were again examined to see if any living scales could be found. After a half hour's careful search, one or two young insects were discovered and a little distance from these was an old scale, apparently the mother-scale, which had doubtless escaped the spray. On another shrub at some distance from most of the infested ones, several old scales were found with numerous young ones in all stages of development.

The fight was again renewed and on November 16, the shrubs were all thoroughly sprayed, the same as they had been earlier in the season. December 8, the spraying was again repeated; each time great care was taken to strike every part of the shrubs with the spray, the one-to-four mixture of kerosene and water being used.

January 4, 1898, the services of Mr. Slingerland were again requested, and on the shrub last referred to a considerable number of scales, mostly young ones, were found alive, although a rough estimate was made that nine-tenths of them were dead.

This shrub upon which the most scales were found is one which was not known to be infested until sometime after whale-oil soap had been applied to the majority of those infested and consequently this treatment was withheld from the shrub. The foliage was dense and it was nearly surrounded by vigorous large-leaved shrubs of other species so that the June and July sprayings were doubtless less thoroughly applied than in case of the others which were more exposed, and in consequence, more readily treated.

When this work was first undertaken it was our hope that a complete extermination of the foe might be the result, and, indeed, the condition of affairs in July seemed to indicate that our hopes might be realized. It is not surprising, however, considering the extreme rapidity with which the San José scale multiplies, that a few of them are now to be found. If only a very small number of scales remained uninjured after the spraying on July 2, the natural result would be a great increase as there was then several weeks in which reproduction would proceed. So the fact that some scales yet remain does not indicate that the method of treatment is at fault; it does indicate, considering the work as a whole, that in certain instances it was not sufficiently thorough.

Comparing the results of the sprayings made in June and July with those made in November and December, it would seem that the earlier applications are the more effective. In July, as already stated, no live scales could be found, although later developments make it apparent that there were at that time a few isolated scales unharmed. The more recent sprayings, particularly the last one, were as thorough as it was possible to make them and while only a few scales are alive at the present time, the number is more conspicuous than was the case in July, hence the conclusion that the scales are more easily killed in the spring than in the fall or early winter. That this is true seems reasonable when we consider that in the spring the scales are in a growing condition while during the winter they are in a dormant state.

Methods of applying the insecticides.—Whale-oil soap in a solution of two pounds of soap to a gallon of water is somewhat difficult to apply. In our work with the San José scale, thoroughness was conceived from the first to be the basis of all operations connected with the spraying, and it seemed best to apply the soap solution with a brush; an old paint brush with stiff bristles was used. This makes an operation of this kind a little tedious but it is surprising how rapidly the work may be done even with a brush; and a no more thorough way could be imagined. When this solution is hot it is sufficiently thin to permit its being applied with a pump, but on cooling, as it will do very quickly in small quantities, it becomes more or less stringy and semi-solid in its nature, so that it is difficult to put it on as a spray.

The kerosene mixture was applied with a Success bucket pump with a kerosene attachment. This pump is made by the Deming Co., Salem, Ohio, and is an acquisition to spraying apparatus. By means of this pump the necessity of making an emulsion with the kerosene is removed.

General remarks.—Diluted kerosene, if as effective as our experience indicates, will have several advantages over whale-oil soap in fighting the San José scale. Not the least important of these is its cheapness when diluted for use, as compared with whale-oil soap, which costs about four cents a pound at wholesale and about six cents in fifty pound lots. The kerosene may be applied to the leaves or buds at any time without injury, while whale-oil soap, in solution sufficiently strong to kill the scales, will injure the foliage and buds and it can be applied only to the trunks and larger limbs except when the plants are thoroughly dormant. Kerosene is more easily applied than whale-oil soap. It is of uniform strength while the qualities of whale-oil soap are quite uncertain.

Pure kerosene has been recommended as a specific for this pest, and doubtless it is, but its effects upon the host plant are less certain. It is a well known fact that pure kerosene may be used on some plants with perfect safety and it has been so used on some of the orchard-hosts of this scale with apparent impunity ; it has also been used with decidedly fatal results to the host.

Natural enemies of the scale.—There are several of these, to which only a passing reference can here be made.

There are several insects which feed more or less upon it and a number of fungi are its parasites, but its most destructive enemies, both insect and fungous, are natives of southern or warm climates and it is doubtful if these can be of much use in combating it in the North. The most destructive enemy, apparently, is a fungus (*Sphaerostilbe coccophila*) which is found in Florida. Its utility as a destroying agent has been studied and reported by Rolfs of the Florida Experiment Station.*

In the first part of this bulletin an attempt was made to point out the necessity of being thorough in the work of spraying. We would again emphasize the close connection which exists between thoroughness and success. As important as this is in all ordinary spraying, it is even more so in attempting to combat the San José scale. The insect is so small and often attached to uneven places on the bark, particularly if the bark is rough and full of little crevices, that it is only with the utmost care that even a large percentage of the scales can be reached by the spray, to say nothing of exterminating the foe, and reproduction takes place with such phenomenal rapidity that one scale will soon give rise to thousands.

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*Bull. 41, Fla. Exp. Sta.

Summary on Treatment of San José Scale.

1. Whale-oil soap used at the rate of two pounds to a gallon of water will kill the scale, but its use is more or less restricted on account of its consistency when cold and from the fact that it injures the foliage and buds if they are in other than a dormant condition. Page 588.

2. Kerosene applied at the rate of one part kerosene to four of water will destroy the scale. Page 588.

3. The results of spraying in the spring compared with those obtained from late fall or early winter applications indicate that the scale is more susceptible to the action of insecticides in the spring than they are in the fall. Page 590.

4. Whale-oil soap in solution may be applied by means of a pump while it is hot, but after it becomes cold a brush or some similar implement is necessary to do thorough work. A spray pump with kerosene attachment is the most convenient apparatus for applying kerosene. Page 590.

5. There are several insects and fungous enemies of the scale but it is yet doubtful if they are of much economic importance in the North. Page 591.

6. The San José scale does not seem to be very difficult to kill when insecticides are brought in contact with it. The difficulty arises chiefly from the fact that the scales are often more or less protected by the roughed bark, crevices and other natural conditions of the host, and from the rapid increase of the pest.

7. Great care and thoroughness are of paramount importance. When the work is thoroughly well done and frequently repeated, satisfactory results may be expected. Page 591.

H. P. GOULD.

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39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf-Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
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106 Revised Opinions of the Japanese Plums, 30 pp.
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129 How to Conduct Field Experiments with Fertilizers, 11 pp.
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131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
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138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report upon Japanese Plums, 15 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a Cause of Death Among Swill-Fed Pigs, 12 pp.
142 The Codling-Moth, 69 pp.
143 Sugar Beet Investigations, 88 pp.
144 Suggestions on Spraying and on the San José Scale.

Bulletin 145. **February, 1898.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

BOTANICAL DIVISION.

Some Important Pear Diseases.

By B. M. DUGGAR.

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In pursuance of the provisions of Chapter 128 of the Laws of 1897, several persons were appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work required.

See Bulletin 146, Report of Progress.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.

CORNELL UNIVERSITY, ITHACA, N. Y.,
March 1, 1898.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY:

Sir:—This bulletin is our first attempt to answer the many questions respecting the diseases of the pear. There is a special reason for taking up the investigation from the fact that the common leaf disease of the pear in this state is a different fungus than has been supposed. The inquiry has shown that two very distinct diseases have been confused, and in the future we should speak of leaf-blight less and of leaf-spot more. The bulletin also calls attention to the dreaded fire blight; and although nothing can be done to directly intercept the disease, the injury may be somewhat averted if the grower's eyes are so sharpened that he discovers the disease upon its first appearance.

I. P. ROBERTS,
Director.

SOME IMPORTANT PEAR DISEASES.

I. LEAF-SPOT.
- 1. General Account.
- 2. Geographical Distribution of the Fungus.
- 3. Occurrence in Orchards.
- 4. Spraying Experiments in the Orchard.
- 5. Occurrence in the Nursery.
- 6. Microscopic Characters.

II. LEAF-BLIGHT.
- 1. General Account.
- 2. Microscopic Characters.
- 3. Occurrence in Orchards, and Remedies.
- 4. Occurrence in Nurseries, and Remedies.
- 5. References to Literature.

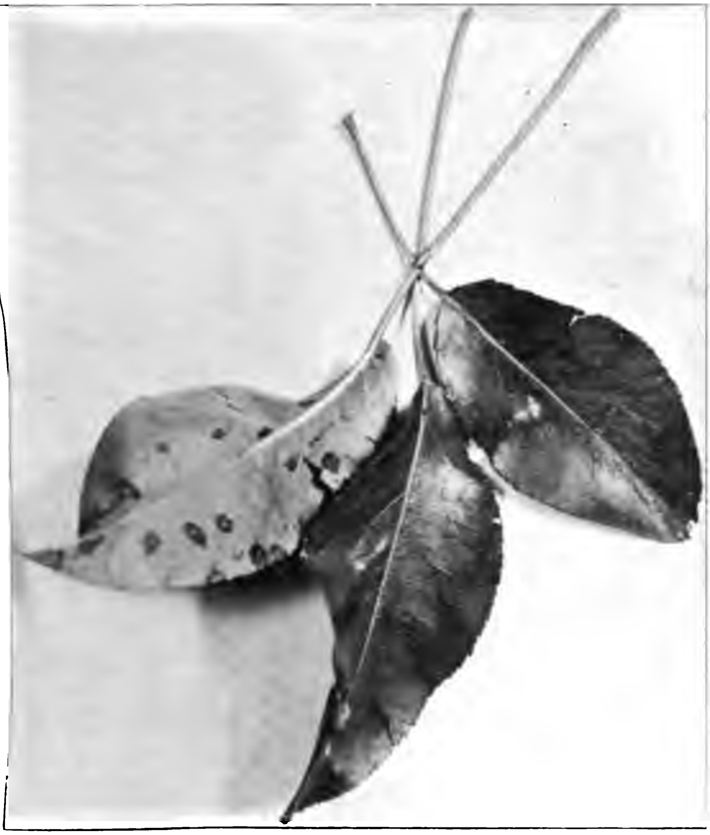
III. PEAR-SCAB.
- 1. General Account.
- 2. Special Characters of the Fungus.
  - (*a.*) *Microscopic Appearance.*
  - (*b.*) *How the fungus passes the winter.*
  - (*c.*) *Does pear scab differ from apple scab?*
- 3. Varieties Affected.
- 4. Remedies.
- 5. References to Literature.

IV. PEAR BLIGHT.
- 1. General Appearance.
- 2. Historical.
- 3. Special Features of the Disease.
  - (*a.*) *The Bacteria.*
  - (*b.*) *Kinds of trees affected.*
  - (*c.*) *Bacteria in the flowers.*
  - (*d.*) *Bacteria in the wood.*
- 4. Remedies.
  - (*a.*) *The knife and the saw.*
  - (*b.*) *When to cut.*
  - (*c.*) *Conditions favoring the disease.*
- 5. References to Literature.

I. LEAF SPOT.*

1. General Account.

In horticultural writings much attention has been given to the leaf-blight of the pear, a disease sometimes called leaf-spot. The leaf-blight is a fungus of wide distribution and of much economic



157.—*Leaves of Anjou pear injured by leaf-spot fungus.*

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* *Septoria piricola* Desm.

importance. Recent critical study, however, shows that an entirely different injurious pear-leaf fungus is very probably much confused with the leaf-blight. I would suggest that the name leaf-blight may well be confined to the well known disease about which so much has been written, and that the term leaf-spot may appropriately be used to denote the fungus to which I wish here to call special attention.

This leaf-spot is not one of those fungi of minor economic importance to be wholly neglected, or which should secure attention at the hands of botanists alone. Nevertheless, in this country it had not been mentioned in the bulletins or other economic publications until the notes sent out from this laboratory last year;[*] yet it has been casually mentioned in several German works.[†] I do not find anywhere, however, that it has received deserved attention from the economic point of view, being entirely overlooked or neglected in this country.

While studying some pear diseases during the summer of '95, Professor Atkinson found this leaf-spot abundant in the orchards of Ithaca and vicinity, and before the close of the summer he observed it at Syracuse and Geneva, where considerable injury was done to the foliage of orchard trees.

During the season of '96 and '97 I have continued observations upon this leaf-spot, and it proves to be a disease of considerable importance, and a fungus widely distributed. To the ordinary observer the character of the spots may not seem to differ materially from those of the leaf-blight, but careful observation will readily distinguish them. The mature leaf-spot as it appears on the green leaves is usually larger, more sharply defined, and somewhat angular, being roughly limited by subdivisions in the venation. See figures 157 and 158.[‡] The spots may show three fairly well differentiated zones of color. The center is grayish white, and herein appear the minute black fruit-bodies, or pycnidia, in which the spores are borne. The next zone is brown, and this often grades into a region purplish in color. The details of these characters are lost in old or dried leaves; but the cluster of fruit-bodies is very evident in the center of the spot on one or both surfaces of the leaf, especially if examined with a hand lens.

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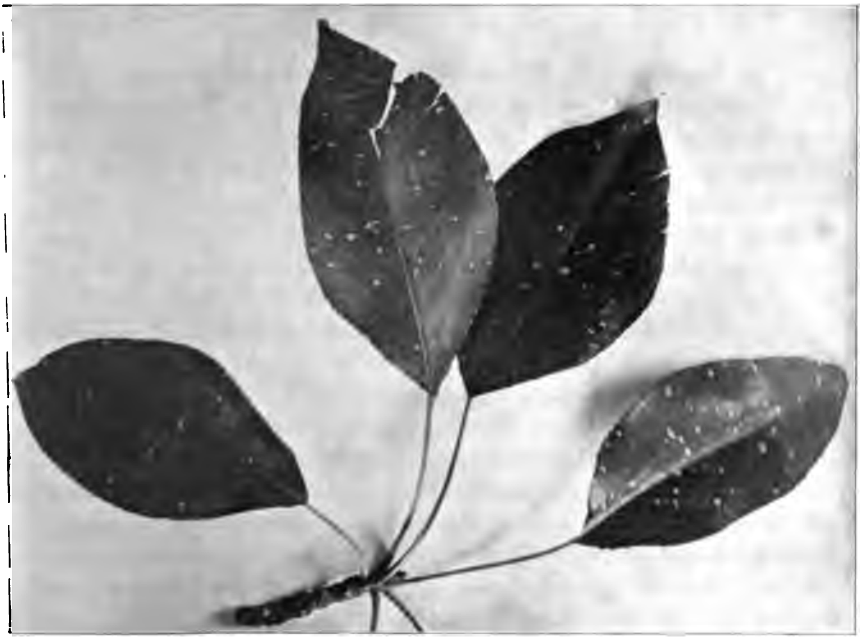
[*] 1)Atkinson, Geo. F.—Leaf-spot of Pear. Garden and Forest, X. pp. 73-74, 1897.

2)Duggar, B. M.—Another Injurious Leaf-spot of Pear. Report Proceedings West. N. Y. Hort. Soc. 1897.

[†] 1)Sorauer, P.—Pflanzenkrankheiten, Zweite Auflage, II. p. 390.

2)Tubeuf, K. F. Von.—Diseases of Plants Induced by Cryptogamic Parasites (English edition), p.

[‡] Figures 157, 166, 168, and the frontispiece are from photographs made by Professor Geo. F. Atkinson.



158.—*Small, angular spots produced by the leaf-spot fungus on an unknown variety of pear in a neglected orchard.*

2. GEOGRAPHICAL DISTRIBUTION OF THE FUNGUS.

There is every reason to believe that in New York State this fungus is to be found wherever there are pears. I have collected it in three-fourths of the counties bordering the N. Y. C. and H. R. R. R. from Buffalo to New York, and it is also abundant in south central portions of the state. It has been sent to me from Pennsylvania, Maryland and Virginia, and pear leaves from Alabama show spots characteristic of this disease, although the immature condition of the fungus render a definite determination difficult. Nevertheless, from the above we are assured of its general distribution in the eastern states, and in many places it is the most abundant leaf fungus of the pear.

3. OCCURRENCE IN ORCHARDS.

By far the majority of observations as to distribution were made upon orchard trees, since these are generally more accessible. Fortunately, there is no evidence to show that this disease ever attacks the fruit, so that there is little danger of losing a growing crop. The foliage of susceptible varieties, however, is often greatly injured by mid-summer, and many trees are partially defoliated in August. At Black Hook I observed a number of yard pear trees more than half defoliated on June 17. At Cayuga large blocks of several varieties were considerably defoliated by the latter part of August, but during the midsummer the leaves were only spotted and somewhat discolored. Under ordinary circumstances, a number of varieties are so slightly injured that the defoliation is scarcely evident before the appearance of frost, unless there are adjacent resistant varieties for comparison. At any rate, many varieties suffer more or less, and even though affected leaves should adhere until after the summer pears are gathered, the injury to the leaf throughout the summer and its fall a month or more before the normal time are sufficient injuries to demand our attention. We must assume that the vigor of the tree is thus reduced for the perfection of its product another year. Only a series of experiments through a period of years could determine accurately the extent of such injuries.

There has been collected a considerable amount of data as to varieties affected, but mostly in small orchards. Such matters are also liable to great variation, and I present a general account merely for the suggestion it may give. In this connection notes on a single orchard are valuable for the comparison of varieties, as far as they go. In the orchard of Mr. H. S. Coleman, of

Geneva, no spraying was done during '96. In round numbers there were about one thousand trees, distributed as to number in variety as mentioned below. In order of injury, this one orchard gave the following results,—defoliation being not very great, even on Oct. 1, it is mainly a comparison of leaf injuries:—

Variety.	Number of trees.	Effect.
Bosc	1–5	Quite bad.
Anjou	100	"
Louise Bonne	10–25	"
Giffard	1–5	"
Buffum	1–5	"
Clairgeau	10–25	Considerable.
Summer Doyenne	1–5	"
Seckel	100	"
Sheldon	10-25	"
Bartlett	100	"
Lawrence	10–25	"
Flemish Beauty	10–25	Slight.
Josephine de Malines	1–5	"
Vicar of Winkfield	1–5	"
Clapp's Favorite	10–25	"
Reeder	1–5	Very slight.
Souvenir du Congress	1–5	"
Duchess	500	"
Winter Nellis	1–5	None.
Kieffer	1–5	None.

On the University grounds the orchard of the department of horticulture was given at least one spraying during the season of '96, but even here the disease was generally prevalent to slight extent. Observations upon this orchard and upon others indicate that among the varieties more commonly cultivated, Anjou, Seckel, Bosc, Summer Doyenne, and Bartlett are very generally affected to considerable extent; Louise Bonne, Clairgeau, Clapp's Favorite, Flemish Beauty, and others much less, falling into an intermediate and variable grade; Duchess uniformly very slightly affected; and Kieffer free from the leaf-spot fungus.

The leaf-blight fungus in pear orchards is apparently not very abundant in this state, and instances of the confusion of the leaf-spot with the leaf-blight have come to our attention. This may account for the statement that the leaf-blight, although of general occurrence in New York, rarely causes cracking of the fruit in this state. Leaf-spot never affects the fruit. Nevertheless, one can not go amiss in the treatment of these diseases, mistaking one for the other, for the treatments as suggested are about the same.

4. SPRAYING EXPERIMENTS IN THE ORCHARD.

For the season of '97 it was decided to make some experiments for the prevention of this leaf-spot. Cayuga seemed our most convenient point, and on visiting some orchards at that place, I found that a small orchard owned by H. S. Wiley contained a number of trees of two desirable varieties, and upon an examination of the old leaves of the previous year, it was found that the leaf-spot had been present to considerable extent. Mr. Wiley consented to having the work done, and put his orchard at our disposal, as well as the use of his barrel pump; and I was assisted in the work by F. T. Wiley.

As originally planned, these experiments were designed to test the effect of three standard fungicides, the number of sprayings necessary, and the best time for spraying. Owing, however, to a difficulty in securing certain materials for the first application, the original plan could not be fully carried out.

The three fungicides used and the formulæ employed were as follows:

Bordeaux.

Sulphate of copper (blue vitriol)	6 pounds.
Quick lime	4 pounds.
Water	50 gallons.

Ammoniacal copper carbonate.

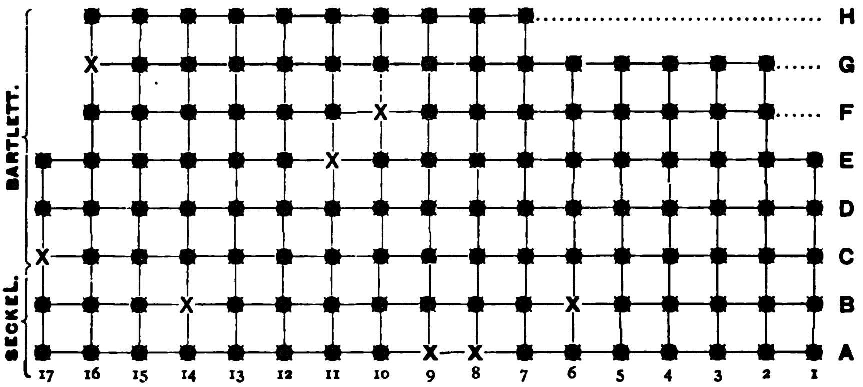
Carbonate of copper	5 ounces.
Strong ammonia	3 pints.
Water	45 gallons.

Liver of sulphur solution.

Potassium sulphide	30 ounces.
Water	50 gallons.

The general arrangement of the orchard is given in the diagram below. The only changes from original settings are that in row A, Nos. 3, 4, and 5 are top grafted to Idaho; in B, No. 1 to Vermont Beauty, and throughout No. 8 the trees are top grafted to Kieffer. Missing trees are indicated by crosses.

The original rows run as indicated by the lettered rows, and the spraying was made across both varieties, hence according to the numbered rows.



Row 1, Ammoniacal copper carbonate, four times, May 6 and 27, June 11, July 17.

Row 2, Ammoniacal copper carbonate, three times, May 6, June 11, July 17.

Row 3, Bordeaux mixture, four times, May 6 and 27, June 11, July 17.

Row 4, Bordeaux mixture, three times, May 6, June 11, July 17.

Rows 5 and 6, Potassium sulphide, three times, May 27, June 11, July 17.

Rows 7 and 9, check, unsprayed.

Row 10, Ammoniacal copper carbonate, three times, May 27, June 11, July 17.

Row 11, Ammoniacal copper carbonate, two times, June 11, July 17.

Row 12, Bordeaux mixture, two times, June 11, July 17.

Rows 13–17 unsprayed.

Row 8 not included (Kieffer).

It is seen that the first spraying (omitted from some) was made before the blossoms were fully open, the next soon after the petals fell, and two sprayings were made during the summer months. Notes were taken on Aug. 3, Sept. 2, and Oct. 5. Defoliation began during August, and on Sept. 2d the unsprayed trees were about one-half defoliated; but detailed notes of this date will not be given, since those of Oct. 5, some time previous to the autumn frosts, will show better the final status of the protection rendered.

Row 1, very slightly affected. Leaves green and fresh.

Row 2, same as 1.

Row 3, almost no indication of spot. Leaves remarkably healthy.

Row 4, about the same as 3.

Rows 4 and 5, affected by the spot to considerable extent, but almost no defoliation by Sept. 1. Badly spotted and slightly defoliated on Oct. 5.

Rows 7 and 9 badly defoliated.

Row 10, slight attack throughout, Seckels showing more injury.

Row 11, badly spotted, about as in 5 and 6.

Row 12, injured throughout, but not so much as row 11.

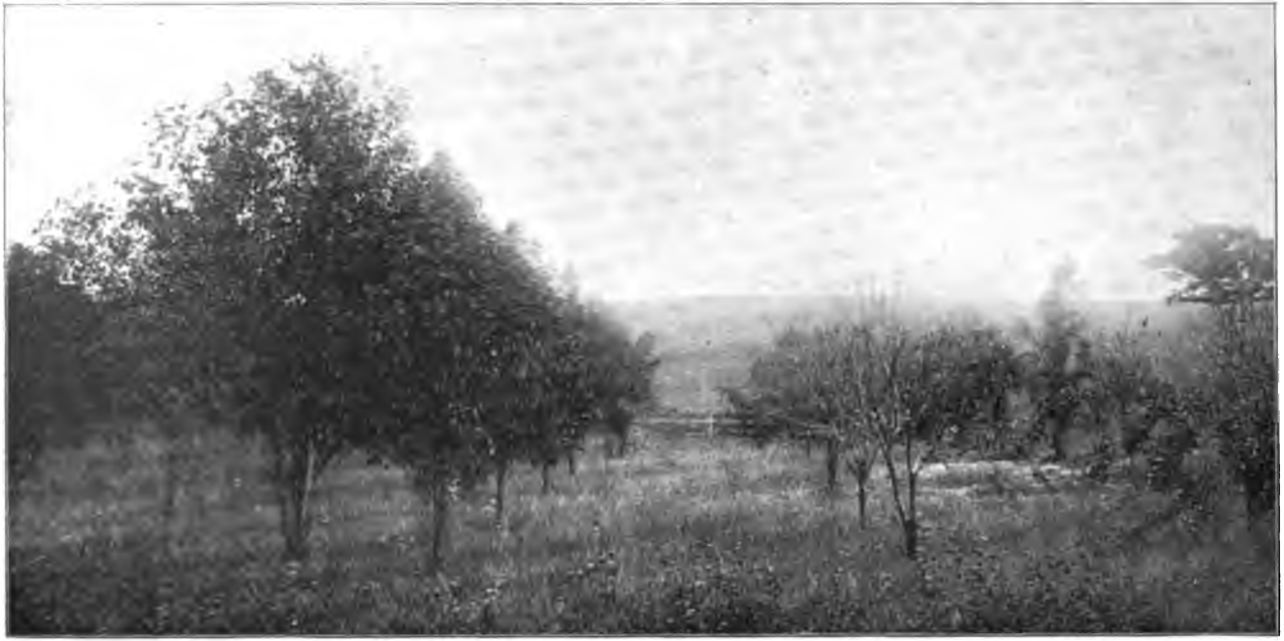
At this time, and even earlier, the difference between the check rows and certain of the sprayed rows was so evident as to be noticed at considerable distance. The sprayed trees maintained their leaves well, and the earliest autumn winds were not sufficient to jar them off. This became so evident late in October, that Mr. Wiley further emphasized my earlier observations by writing me. "The trees you sprayed (that is the fruiting pear trees) have retained their leaves most remarkably, while the others are now all defoliated."

Figure 159 shows, in the center, rows 3 and 4 sprayed with Bordeaux; and on the right, rows 1 and 2, sprayed with ammoniacal copper carbonate.

Figure 160, at the center, gives comparison between the check, on the right, and three sprayings with ammoniacal copper carbonate on the left.

Summarizing the spraying experiments, it is well to suggest that three sprayings with Bordeaux gave almost perfect protection against the leaf-spot. This spot may probably be quite effectually treated by the usual treatments given for pear scab. Where the codling-moth, but not the scab prevails, the first treatment may be made in conjuction with the Paris green application, immediately after the petals fall, and two subsequent sprayings at intervals of two or more weeks, if thoroughly done, would secure protection throughout the season, it appears. My obser-

159—*Central two rows sprayed with Bordeaux. Rows to the right sprayed with ammoniacal copper carbonate.*



160—*In the center, to the right, is row 9, unsprayed; and to the left, row 10, sprayed three times with ammoniacal copper carbonate.*

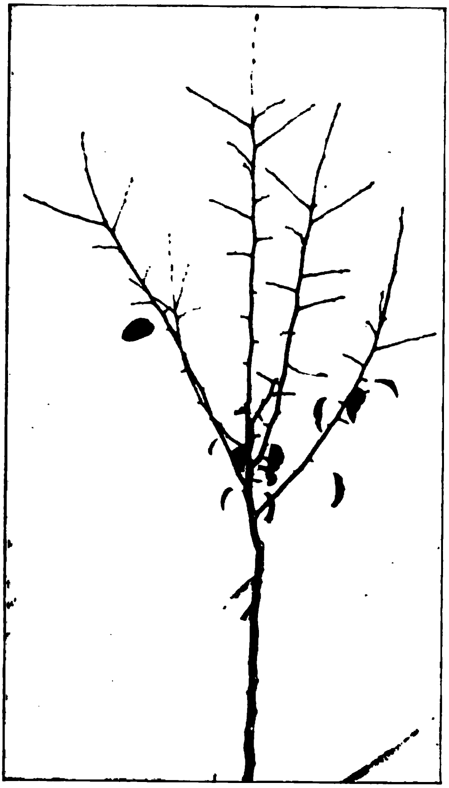
vations have been, moreover, that neglected orchards, trees in turf and in small garden lots are more affected than a properly cultivated orchard.

5. OCCURRENCE IN THE NURSERY.

The principal nursery regions which I have examined in this connection are those in the vicinity of Dansville, Geneva, and Cayuga. While the leaf-blight is the financial bane of seedling pears, this leaf-spot is uniformly the fungus monopolist of budded stock after the first year. Budded stock of two years or older is often badly injured late in the summer, and occasionally I have found the leaf-spot to a considerable extent upon one year stock. Although well aware of its presence, nurserymen as a rule do not consider this sufficiently injurious to warrant their attention, especially as there is greater difficulty in spraying the stock of the second year; but many realize that it would be desirable to spray. Some make a practice of spraying the one-year stock early in the season, but those who do this are few, and the fact remains that it suffers less injury than older stock. As to the cause of this apparent immunity, several prominent nurserymen agree that with an abundance of room and with the

161—*Sprayed late with Bordeaux.*

good culture usually given the first year, the plant finds such favorable conditions as readily to hold the mastery. This is authenticated by my observations on older stock, which seem to be less affected when the culture has been well attended to. Nevertheless, the spot is abundant on certain varieties in spite of any culture which I have seen.



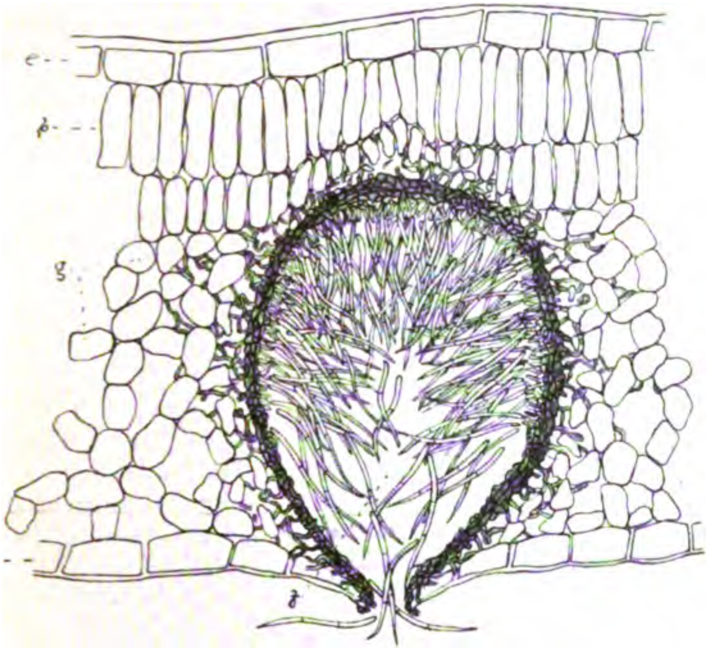
162—*Sprayed with ammoniacal copper carbonate.*

Extensive notes have been taken as to the extent of injury among the different varieties, but there is so much variation that no definite statement should be made at present. Certainly, however, thus far Anjou, Seckel, Sheldon, Summer Doyenne, Dana's Hovey, Frederick Clapp, and Bartlett have shown the greatest injury, somewhat in the order named; Duchess very slightly affected, with Kieffer quite free; and all of the remaining varieties ordinarily grown suffer more or less.

Spraying experiments on rather old nursery stock were also begun at Cayuga, but through an unfortunate misunderstanding most of the stock was removed after the second spraying, and the only result of interest is the comparison between a few Seckels and Anjous, sprayed late with Bordeaux and ammoniacal copper carbonate respectively. Figures 161 and 162 indicate these comparisons.

6. MICROSCOPIC CHARACTERS.

A thin section through a diseased spot* is shown in figure 163. Here we see at *e* the outer cell layer, or epidermis, of the leaf on both sides. At *p* is shown the palisade layer of cells often containing so much of the green coloring matter of the leaves,



163.—*Cross section through a leaf-spot, showing the fruit body and spores of the leaf-spot fungus.*

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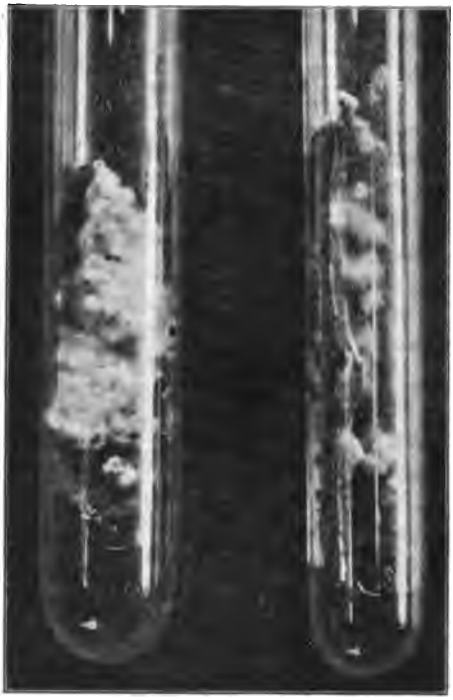
* Portions of leaves showing the fungus, after being properly fixed and dehydrated, were imbedded in paraffine, sectioned, and stained. The Ehrlich-Biondi-Heidenhain conbination works well, staining green the deadened host cells and older hyphal elements, while the basidia, younger hyphæ, and fresher leaf tissues are colored red. A carmine and nigrosin combination also works well.

The spores do not germinate very readily in agar alone, but I have secured abundant germination in agar containing pear-leaf decoction. Isolated spores were then removed to bean-stem and pear-stem cultures.



164.—*Cultures of the leaf-spot fungus on pods and stems of bean.*

and below this the general leaf tissue, *g*. *f* is a section through the hollow mature fruit body, or pycnidium, containing the countless spores. Each spore was originally borne on a little pedicel, or basidium, which seems to grow out from the wall. When the pycnidium is ripe, water is absorbed, and these masses of spores ooze out of the mouth of the pycnidium in a long horn-like projection, very dark in color. Here, then, they are at the surface ready for dissemination. With suitable conditions of moisture they germinate readily upon other pear leaves. Some germinating spores highly magnified are shown in figure 165. The germ tubes arise from either end (*c* and *d*), or

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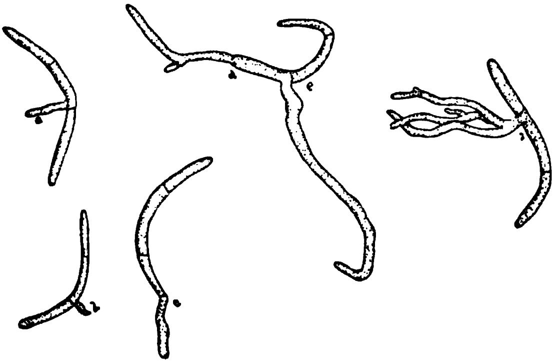
Here the fungus grew slowly at first, producing after several weeks the pycnidia of the *Septoria*. After several transfers this fungus grows quite luxuriantly on bean pods or stems, as seen in figure 164, producing the pycnidia in a short time, and the pycnidia are then not so definite in form but formed of a very loose stromatic mass. The submerged hyphæ are dark in color, while the aerial growth is dense and white, except the stromatic mass inclosing the pycnidium. I have had cultures for eighteen months; and although they have been subjected to various climatic conditions, nothing of further interest has as yet come from them. In nature the fungus is being closely watched for other stages, but I can say nothing definite upon this point at present, although other fungi have been found on the old leaves.

This *Septoria* is very evidently to be referred either to *S. piricola* Desm.



165.—*Germinating spores of the leaf-spot fungus.*

from the middle (*a*, *b*, *e* and *f*) of the spore, and readily penetrate the tissues of the leaf for the final production of another leaf spot.

II. LEAF BLIGHT.†

I. GENERAL ACCOUNT.

The above disease has been known in this country for many

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or to *S. nigerrima* Fuck. Through the kindness of Professor W. G. Farlow, the American specimens have been compared with *S. piricola* in Desmaziere, Herbier de la France, and with *S. nigerrima* in the Mycotheca Universalis and in the Klotzsch collection No. 1755, to which Fuckel referred his nigerrima in the original description. Dr. Farlow would not regard the European specimens as distinct species ; and our American form he finds, differs, if at all, only in that the spores are somewhat more nearly alike at both ends, whereas the European specimens may be somewhat blunter at one end. I have also compared the American specimens with No. 2259 of the Rabenhorst Fungi europaei, labeled *S. piricola*, and the two are identical. It will be noted that Saccardo doubts the distinctness of these two species from his query concerning the difference of color in the cirrae. In *S. piricola* they are described as white to olivaceous, while in *S. nigerrima* they are given as black. This, however, may be of slight importance since the description is evidently incomplete. The American specimen and the Rabenhorst are both 2-septate, thus agreeing further with the published description of *S. piricola* Desm.

† *Eutomosporium maculatum* Lev.

decades, and throughout this period it has figured in horticultural discussions. During the past ten years it has been freely discussed from the practical and scientific point of view in various publications of the U. S. Department of Agriculture, and in many bulletins of the various Experiment Stations. It will not be amiss further to emphasize the results of general interest, especially in connection with the notes already given concerning the leaf-spot. The leaf-blight is well known wherever the culture of the pear has been introduced, and since what is probably the same fungus occurs abundantly on the quince and some other members of the rose family, it finds abundant host plants for fruitful propagation in almost any region.

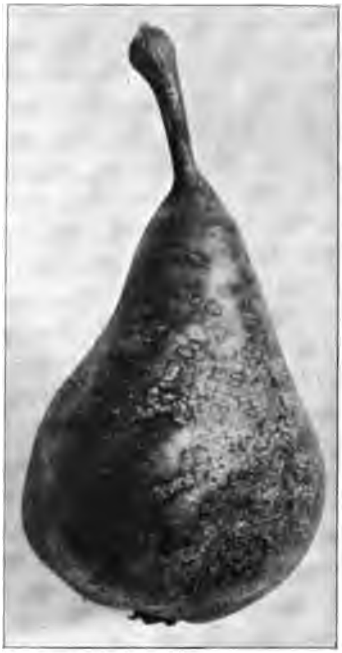
The spots are very evident on the upper surface of affected leaves. They occur at first as small discolored areas, becoming dull red with darker margins. Singly they are small with circular outlines ; but often they are clustered together, or merged one into another. With age the spots are darker, losing some of their characteristics. The leaf often becomes yellowed or browned, and is readily detached from the branch by jarring. There may be seen in the center of the spots at maturity a minute dark papilla. As noted later, it is herein that the spores are borne.

The spots of this fungus are usually smaller than those of the leaf spot, more nearly circular, and not so clearly defined on the under surface.

On the fruit the spots of the leaf blight are red at first, but soon becoming darker. The drying of the epidermal layers of cells may cause a cracking of considerable extent, as in the case of pear scab, an injury from which rotting may readily ensue. The term cracking is no more to be applied to this disease, however, than to the scab. Figure 166 shows a pear merely spotted by the disease.

2. MICROSCOPIC CHARACTERS.

Making a thin section through the spot of this leaf blight where the blackened papilla is noted, authors have described the spores as massed just beneath the cuticle. These minute spores are very unique in form, which to the imaginative mind of an early botanist suggested a minature insect well provided with feelers ; hence the generic name of the fungus, *Entomosporium*, expresses this resemblance. See figure 167 for individual spores.


167.—*Pear injured by the leaf-blight fungus, showing no indication of cracking.*

The mycelium, or vegetative threads, of the fungus penetrate the epidermal layer, and to some extent the general tissue of the leaf, breaking down the cells considerably in that region of the leaf showing the spot.

With proper conditions these spores germinate readily, and ultimately produce again the spot wherever they secure an entrance into the tissues of the leaf. Sorauer claims that from the germination of the spore to the appearance of mature spores in the spot it may induce, about one month is required.*

3. OCCURRENCE IN THE ORCHARD AND REMEDIES.†

The leaf blight has proved a pest to orchardists throughout the country, yet it has been less injurious in New York than in many states farther south and west. I find it more abundant in the Hudson Valley than in other sections of New York. It seems to attack quite generally the varieties more commonly cultivated, although Duchess and Kieffer have often been reported resistant. Many varieties in one place reported free from the disease are reported badly injured in other sections.

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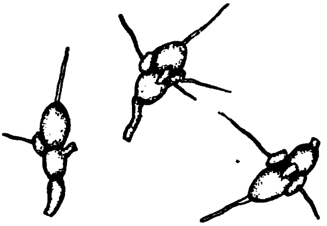
* NOTE. Sorauer has described at length a winter form or perfect stage of the *Entomosporium* which he has called *Stigmatea mespili*. On wintered leaves of quince Professor Atkinson has also found this fungus, and he has suggested referring it to the discomycetous genus *Fabræa*. See Garden and Forest, l. c.

† It is to be noted that in this connection we can refer to the results only as published, but owing to the comparative abundance of the leaf-spot in a few eastern states where the leaf-blight only has been reported upon, there is danger that some important mistakes have been made.

Experimental work at various places throughout the country has shown that the Bordeaux mixture is the most efficient fungicide. Results obtained by the Division of Vegetable Pathology, both in nurseries and orchards, are especially encouraging. Work on a large orchard in Virginia, during 1893, made it clear that for the particular region early sprayings alone did not at all suffice, and that no very early applications are necessary for the treatment of this disease in the orchard. Unsprayed trees were badly defoliated early in August, while trees which received two rather late spray ings—one after the leaves were well formed, and another within the course of a month—these were well protected. If thoroughly done, two sprayings seem to suffice. From the above piece of work, moreover, we learn that in treating 16,000 trees, the cost for two sprayings was less than two cents per tree. As mentioned in connection with the other pear diseases, the 50-gallon formula of Bordeaux is to be recommended.



167.—Spores of the leaf-blight fungus.

4. OCCURRENCE IN NURSERIES AND REMEDIES.

In the nursery the principal damage is done to seedling pears, and further injury is usually to be attributed to the leaf-spot. As previously mentioned, the budded stock is much less frequently affected by the leaf blight. Seedling pears throughout the state, and generally throughout the country, suffer seriously from it. The youngest foliage is first affected, and often the leaves fall early in the season. Later in the season, the sunken reddish areas on the tips of the branches indicate the disease on those parts, and Sorauer has shown that in the latter places the disease may readily pass the winter. In this country Fairchild has also corroborated these views.

The premature hardening or ripening of the young wood prevents the budding operation; or, if budding is not entirely prevented, the early cessation of growth in the formative cambium of the stock renders a perfect union of the woods difficult to secure.

The results of all properly conducted experiments upon nursery stock indicate that Bordeaux mixture as a fungicide is essential to success where this disease prevails. Five or more sprayings have not given perfect protection; but they have been extremely profitable on the American, French, and Japan stocks generally. In large nurseries, and with horse-power machines, the cost should not exceed twenty-five cents for each one thousand trees.

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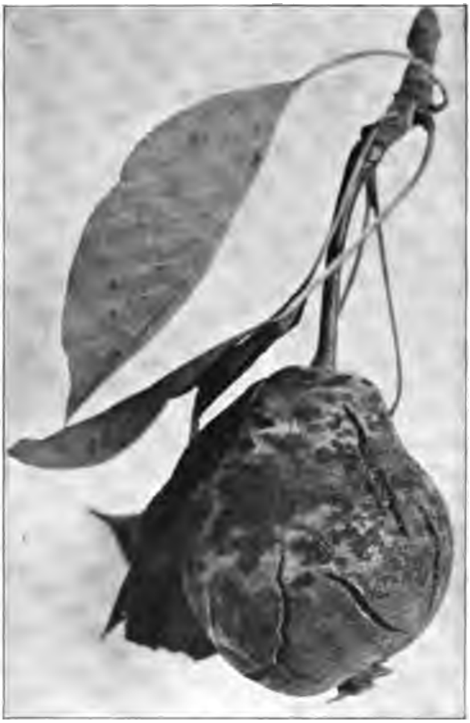
* See, also, bibliography of pear scab.

III. PEAR SCAB.*

1. GENERAL ACCOUNT.

During the past two years a number of inquiries have been received concerning pear scab, and among the smaller orchardists or others with a small number of trees, equally as many inquiries have related to the well-known pear blight. Consequently, it has seemed well to incorporate in this bulletin such brief accounts of these two diseases as will give the information desired.



168.—*Summer Doyenne badly injured by pear-scab.*

The injurious effects of pear scab are well understood by many orchardists; and by some the disease is combated faithfully and successfully, but to others it is an inevitable attendant of pear culture. During the past summer I was surprised to find how often pear scab is confused with certain insect punctures and other minor injuries. I presume, however, that no one who ever grew so susceptible a variety of pear as the Flemish Beauty could long remain ignorant of the scab. The pear shown in figure 168, is from a photograph of a Flemish

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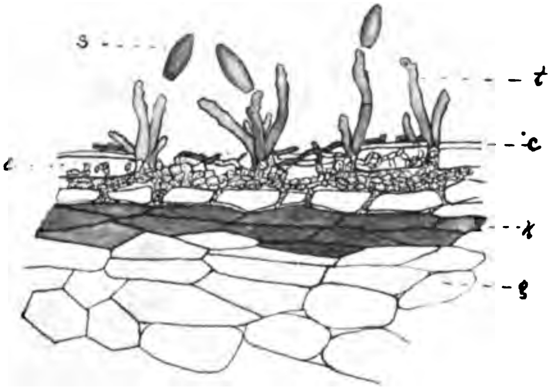
**Fusicladium pirinum* (Lib.) Fckl.

Beauty. Although much is lost when colors are not reproduced, one sees there the essential characteristics of the scab in pronounced form upon the fruit.

With many varieties of pear, this cracking may accompany the scab as well as the leaf blight, or, apparently even certain irritating external agencies may produce the cracking, provided the respective agencies affect the pear during the growing period.

On the fruit the pear scab produces at first merely brownish or olivaceous markings. These discolorations are due, in part, to a short surface growth of the fungus, and to the deadening of the epidermis of the pear. Summer Doyenne, illustrated in the frontispiece, shows the characteristic appearance before there is any indication of cracking.



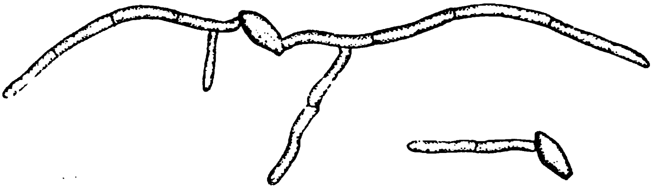
169.—*A cross section through a scab spot on pear fruit, giving the location and the appearance of the fungus.*

The figures do not show clearly any of these spots upon the leaves, but the leaves are often severely affected, the spots being usually more abundant in the neighborhood of the midrib on the under surface. During the past year Professor L. H. Bailey received from Michigan some leaves so badly affected that the fungous growth covered the greater portion of both surfaces, and the leaf was considerably curled therefrom.

Pear scab has been known botanically since 1832, when it was found in Belgium ; but it is only within the past twenty years that it has had a place in economic literature. Hereafter, at least until unsusceptible and otherwise satisfactory varieties are introduced, to the successful orchardist a knowledge of scab is as essential as a knowledge of pruning.

2. SPECIAL CHARACTERS OF THE FUNGUS.

(*a.*) *Microscopic appearance.*—The olivaceous growth on the fruit, leaves, and twigs is largely made up of short erect threads somewhat uneven at their tips. These threads produce the spores or reproductive bodies. A thin section through a scab spot on the fruit examined under the microscope shows what I have represented in figure 169. Over the entire surface of the pear, as of plants in general, there is a definite outer layer of cells which we call the epidermis, as shown at *e*. The outer wall of this epidermal layer usually becomes thickened into a very tough resistant cuticle, *c*, figure 169. Inside of the epidermal layer of the pear we find the pulpy cells and the gritty cells of the fruit without special regularity, as at *g*. In the diagram it will be seen that the mat-like mass of fungous threads is developed largely just beneath the epidermis,* and they never



170.—*Germinating spores of the pear-scab fungus.*

It will be seen that the above description of the location of the hyphæ is somewhat different from that given by several authors. Sorauer states that the stroma occupies mainly the epidermal cells in apple scab. Aderhold† in his interesting paper on the Fusicladia finds the hyphæ always subcuticular at first, and mainly subcuticular throughout. My sections, made from pear fruit only, show that the principal stroma in this case is undoubtedly at first subepidermal. The sections studied were made from material imbedded in paraffine, and they were stained with the Ehrlich-Biondi-Heidenhain mixture.

*Pflanzenkrankheiten, Zweite auflage, II, 394.

†Aderhold, Cf. Bibliography.

extend very far into the pulp of the pear. They often penetrate the cells of the epidermis, deriving their nutriment entirely from these outer layers. The erect threads *t*, figure 169, arise from this mass of threads, break the cuticle, and produce the spores as seen at *s*. Later, the epidermis is ruptured, and then we find that a definite corky layer has been formed by the cells of the fruit below the diseased area, figure 169, *k*.

Figure 170 shows how these spores germinate. After falling upon the leaf or the fruit, with suitable conditions, the spore absorbs water, and pushes out a little thread, or germ tube. This germ tube has the power of passing in through the cuticle and epidermis, where it branches greatly and develops the thread-like mass of fungous hyphæ, and soon again the scab spot is seen on the surface.

(*b.*) *How the fungus passes the winter.*—It has been seen that pear scab often attacks the twigs of the first year. The fungous threads are extremely resistant, and buried in the bark of the twigs it is generally admitted that the disease may thus pass the winter, producing the following spring a crop of spores to reinfect the young branches and leaves, as well as the fruit clusters. It is also believed that the fungus may pass the winter in the diseased fruit and leaves. In Germany a winter stage of the fungus has been found belonging to the genus *Venturia.*

In artificial cultures on bean stems and other nutrient media, I have grown for some time the fungi of apple and pear scab. These cultures have yet given no indication of this other fruiting stage, or winter form of the fungus.

(*c.*) *Does Pear Scab differ from Apple Scab?*—It is well known that pear scab differs from apple scab in some particulars; but some have claimed that these differences are so small as not to denote that the fungi are distinct. However, it is of considerable practical importance to know that some recent work tends to show that these fungi are distinct species; hence, if this is true, pear scab cannot spread to the apple, and there cause apple scab, or vice versa.

3. VARIETIES AFFECTED.

Scab affects to a greater or less extent a number of the varieties commonly grown in New York. The data upon this subject are limited, but it is generally reported that Le Conte, Kieffer, and Bartlett are less attacked than such varieties as Anjou, Lawrence, Duchess, Clairgeau, Sheldon, Seckel, Summer Doyenne, Flemish Beauty, and Jones. On Seckel, Flemish Beauty, and Summer Doyenne I have found it very abundant during the past two years. In a list of about twenty-four varieties given by Beach in bulletin 84 of the N. Y. State Exp. Sta. we find none other than the three mentioned included among those only slightly attacked.

4. REMEDIES.

Since we may assume that this fungus lives over winter in the young branches or diseased fruit, it is quite evident that there is all the more reason for beginning any work of prevention at the earliest time expedient. Fairchild found that before the flower buds open the young scab spots may appear upon them. It is very important to prevent the early establishment of the disease; for once having secured a foothold, spores are rapidly produced and dissemination is very rapid during seasons favorable for the disease.

For the prevention of this fungus, many experiments have been made at various stations with the different fungicides. During the past few years special attention has been given to pear scab at the Geneva Station in New York. The final results are not at all discordant with those of other stations, and recommendations are made somewhat accordingly. Spray three times with Bordeaux mixture of the 50-gallon strength.* The first spraying should be made before blossoming, but after the fruit buds burst; the second, immediately after the petals fall; and the third, about two weeks after the second.

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* See page 604. Beach recommends the 66-gallon formula.

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PEAR BLIGHT*. (*Fire Blight.*)

1. GENERAL APPEARANCE.

Of all the diseases which affect the pear, there is no other which commands attention like the pear blight, or so called fire blight. One may say that it commands attention, for surely its injuries are usually sufficiently evident,—the progressive blackening of leaf and twig, or the death of the tree limb by limb,—injuries which must appeal to any one with due interest, either aesthetic or pecuniary. The most evident cases of blight are at first manifest on the tender shoots or younger twigs by the blackened leaves and withered stems ; gradually the progress of the disease is downward, an inch more or less each day, it may be ; and finally the death of largest limbs may point out the very destructive course of this malady.

With the more susceptible varieties, and under conditions favoring more succulent growth, blight may involve the entire body of the tree. Often, however, the disease is temporarily or permanently checked at definite places by the denser wood or other conditions, and at such places there is a sharp line of demarcation between the healthy part below, and the shriveled, blackened part above. In larger limbs, this break is quite as evident by the cracked appearance of the bark.

Unfortunately, the forms of injury above described are not the only ones. Those who have suffered by this disease know well that frequently the blossoms and the young fruit turn black and dry up. The disease may then remain in the fruits alone, or it may here, also, extend itself to larger limbs through the fruit spurs and twigs.

2. HISTORICAL.

Pear blight has probably been known in this country for over a century. It was crudely attributed to one or another of countless causes until 1880. At that time, through the studies of

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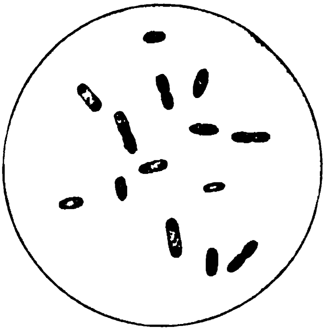
* *Bacillus amylovorus*, Burrill.

Professor T. J. Burrill, of the University of Illinois, we became acquainted with the indisputable means by which this disease is induced and disseminated. The germs of pear blight belong to that class of minute organisms known as bacteria, so many species of which are concerned in the many contagious diseases of man and animals, and so many others useful in various processes of fermentation. From 1883 to 1887, while connected with the Geneva station, Arthur greatly increased our knowledge of this disease. Lastly, Waite, of the U. S. Department of Agriculture, has cleared up many points regarding the disease in the flower, its spread by bees and other insects, with added suggestions concerning its eradication.

3. SPECIAL FEATURES OF THE DISEASE.

(*a.*) *The Bacteria.*—We may well dwell upon some of the interesting points concerning the life and action of these pear blight bacteria. Often when young shoots are affected, slight ruptures in the bark may be noted, and from these ruptures may be exuded minute gummy droplets. Examining under high powers of the microscope such exudation, or even the sap from diseased parts, we find innumerable little oval bodies floating about singly or in chains of two or more, each individual being a plant with great power of rapidly growing longer and dividing again and again into similar simple bodies, see figure 171. These individual bacteria are so small that it requires a mass of them to be evident to the unaided eye; indeed, to attempt to see the individuals in the little gummy droplet, or in the sap, would be like an attempt to see the separate rain drops in the approaching storm more than a mile away.



171.—The bacteria of pear-blight.

Nevertheless, we can grow these bacteria in large quantity upon slices of cooked potato, beef broth, and many other culture media. Here, with certain precautions, they may be grown entirely free from other germs,—in pure cultures. Then these cultures may be used to inoculate healthy twigs, and the production of the disease in the latter gives all needed evidence of the true cause. These inoculation experiments were made by Burrill, and they have been confirmed time and again; so that, (1) finding these disease germs in affected twigs, (2) securing pure cultures of them, (3) by inoculation producing the disease, (4) characterized by the same germ,—these make the cause undoubtable. Thus we learn, also, that the disease is contagious, and that we need to take precautions against its spread.

(*b.*) *Kinds of trees affected.*—By means of cross inoculations from tree to tree it has been abundantly shown that the fire blight, or twig blight, of the apple, quince, and crab; of the mountain ash, service berry, and several species of hawthorn are all due to the same organism; and hence the disease may spread from one to the other. During the past two years, I have found it attacking a Japanese Hawthorn and *Pirus Kaido*. In short, this blight is a disease of many pomaceous plants of the rose family.

(*c.*) *Bacteria in the flowers.*—Waite has shown that these bacteria will grow freely in the nectaries of the pear flowers, later penetrating into the solid tissues of flower, fruit, and stem. By the agency of bees, which feed upon this nectary, the disease may be abundantly disseminated during the blossoming period; but the bees are essential for cross pollination of the flowers.*

(*d.*) *Bacteria in the wood.*—The germs cannot enter the older tissues except through abrasions of the bark, and it is believed that there must be some insect or other slight injury in order that they may enter even the growing tip. The leaves afford no inlet for them, and localized trunk injuries may have been established by means of young shoots or water suckers.

In order to understand how these bacteria may pass downward, once having gained entrance, we must recall the structure of a limb. Just between the soft bark and the wood is a layer of growing tissue, the cambium, which develops each year a layer of new wood on the inside, and a layer of new bark on the outside, so that all of the young active tissue is very closely connected. The younger inner bark however is the favorite region for the bacterial growth containing as it does much nutritive material.

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*Waite, M. B.—The Pollination of Pear Flowers, Bulletin 5., Div. vegetable Pathology, U. S. Dept. Agr.

Sometimes the cambium is also affected. In these tissues the bacteria grow abundantly, passing gradually from cell to cell and destroying much of the living portion of the branch as they go ; but never circulating rapidly from branch to branch. The surface is reached by means of the little cracks through which the gummy exudations arise.

4. REMEDIES.

(*a.*) *The knife and the saw.*—With a disease working as this does, it is very evident that there is no chance either for cure or prevention by means of spraying. The heroic treatment of the knife and saw must be adopted and vigorously pursued, as has been claimed from the beginning. The blackened leaves, alone, must not serve as signs of the diseased area, but one must examine carefully the branches and remove them six inches or more below the lowest discolorations. Often before cutting, pruners slice the bark downward to see where the injury ends. This should not be done; it is better to be sure that you are below the infected area, and run no such risk of infecting anew the tissues below. The cut surfaces of larger limbs and branches should be painted for protection against wound rots.

(*b.*) *When to cut.*—Cutting out diseased portions should be done whenever the disease is evident. This may check the injuries temporarily; but it has been shown that much can be done in the autumn to prevent the establishment of the disease the following spring. It has long been known that the disease may pass the winter in the branches by a slow growth in the neighborhood of late infections. Thorough work of eradication should especially be performed after the season of growth. Then cut out every diseased branch and burn, so that in the spring when the succulent growth begins again, there will be few places in which insects may come in contact with the bacterial exudations. Sometimes trees which are affected during the summer and autumn show no indication of the disease the next year, and

I have observed this especially in the case of hawthorn and apple; but it seems much more likely to pass the winter in the pear.

(*c.*) *Conditions favoring the disease.*—The knife is our only hope of extermination; but there are undoubtedly conditions which favor the disease. In a succulent, rapidly growing tree the bacteria find more favorable conditions for their development than in one which grows slowly, yet with sufficient vigor. For this reason, too much nitrogenous manure is dangerous; and, for the same reason, a succulent growth induced by severe pruning should be avoided. It has been demonstrated by experiment that withholding water from potted trees which had been inoculated with blight would immediately stop the course of the disease.

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39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
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141 Powdered Soap as a cause of Death Among Swill-Fed Pigs, 12 pp.
142 The Codling-Moth, 69 pp.
143 Sugar Beet Investigations, 88 pp.

Bulletin 146. February, 1898.

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

ALL DIVISIONS.

FOURTH REPORT OF PROGRESS
ON
EXTENSION WORK.

(BEING A REPORT OF WORK DONE UNDER CHAPTER 128, LAWS OF 1897, OF THE STATE OF NEW YORK, OTHERWISE KNOWN AS THE NIXON BILL.)

BY I. P. ROBERTS.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

ORGANIZATION OF THE EXPERIMENT STATION.

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In pursuance of the provisions of Chapter 128 of the Laws of 1897, several persons were appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work required.

See Bulletin 146, Report of Progress.

Office of the Director, 20 Morrill Hall.
The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Report of Progress.

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A. R. Ward,	Dairy Bacteriology
C. W. Mudge,	Agricultural Chemistry
Edward A. Butler,	Accountant
Julia Z. Kelly,	Stenographer

Some of the persons comprising the Working Staff have given all their time to the work, and others have been employed for only a few months, or for a few lectures or other special duties.

The efficiency of the work has been promoted by the helpful co-operation of the Secretary of Agriculture, Honorable James Wilson, Director A. C. True and Professor H. W. Wiley, of Washington, D. C. No less helpful has been the hearty support of the Commissioner of Agriculture, Honorable Charles A. Wieting, and the Superintendent of Education, Honorable Charles R. Skinner, and their associates. But most of all do we desire to acknowledge thanks to the many citizens of the state who have so appreciatingly received the instruction and to those who have so heartily entered into the work of investigation.

THE PROGRESS OF THE STATE EXTENSION WORK IN AGRICULTURE.

(*Work done under Chapter 128, Laws of 1897, known as Nixon Bill.*)

PART I.

INVESTIGATIONAL WORK.

A bulletin (No. 137) was issued in May, 1897, on the Origin and Progress of Agricultural Extension Work. Preliminary reports were made in bulletins 110 and 122.

The present bulletin is issued for the purpose of recording as briefly as possible the work done from May 1st, 1897, to February 1st, 1898. The scope of the work under Chapter 437, Laws of 1896, set forth in Bulletin No. 137, was somewhat restricted since the law required that the money appropriated should be expended in the Fourth Judicial Department in investigations and experiments and for disseminating horticultural knowledge by means of schools, lectures and bulletins.

Chapter 128 of the Laws of 1897 provides for carrying on work throughout the entire state as follows:

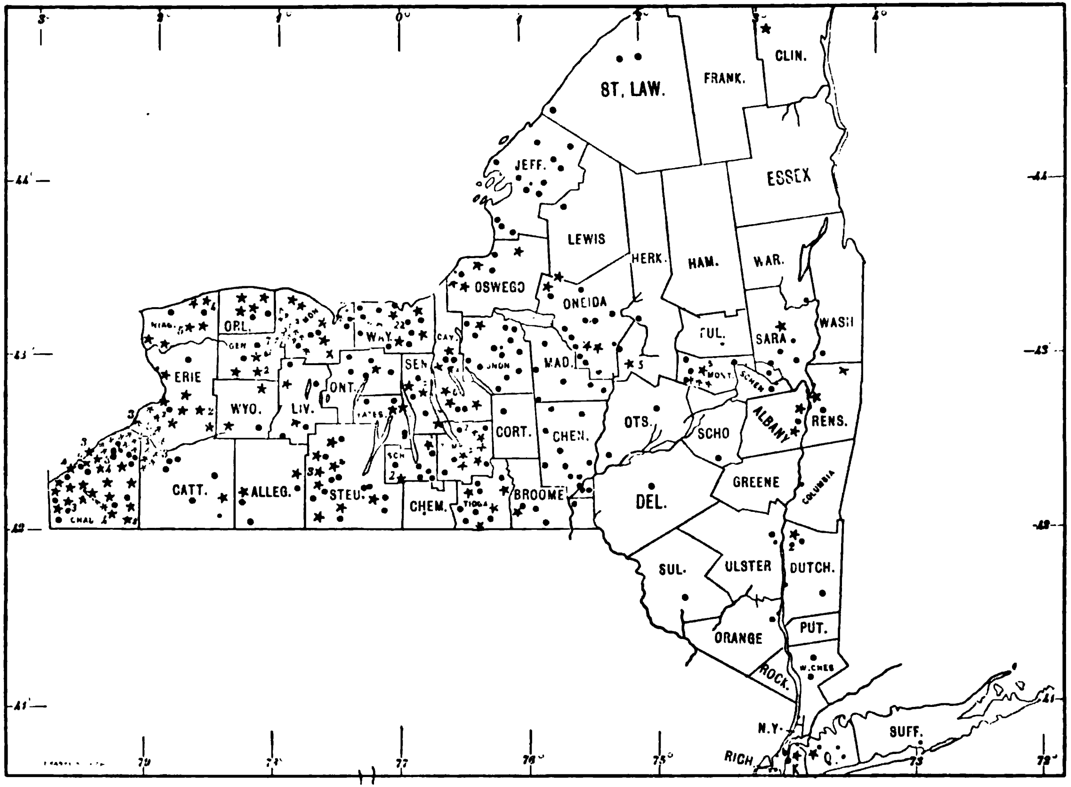
"In giving instruction by means of schools, lectures and other University Extension methods, or otherwise, and in conducting investigations and experiments; in discovering the diseases of plants and remedies therefor; in ascertaining the best methods of fertilization of fields, gardens and plantations; and best modes of tillage and farm management and improvement of live stock; and in printing leaflets and disseminating agricultural knowledge by means of lectures or otherwise; and in preparing and printing for free distribution the results of such investigations and experiments, and for republishing such bulletins as may be useful in the furtherance of the work; and such other information as may be deemed desirable and profitable in promoting the agricultural interests of the state."

The contemplated work was planned with care but there were many unknown conditions; therefore the scheme was pliable and provided only for the work contemplated for six months, at the end of which time it was adjusted to meet the actual conditions and wants which were then found to exist.

The work under the Nixon Bill has been thrown into two general categories,—that which is primarily investegational, and that which is more directly educational. Brief reports of progress in the investigational work have been furnished by the divisions having the special subjects in charge. In some cases much of the work has been done by the head of the division ; in others, it has been carried on by assistants under his direction.

It is impossible to fully set forth in this brief space the full scope of the investigations completed and now in progress. The work has been unusually fruitful in results which have either been set forth at length in bulletins, or will be published in the near future.

Following are reports of the various departments concerned in the investigational work :



172.—*Showing the postoffices at which sugar beet investigations have been made.*

* Shows location of sugar beet experiments.
● Shows location of fertilizer experiments.
The numerals indicate the number of experiments at the different points.

The Work in General Agriculture (*I. P. Roberts, Chief*).

BY J. L. STONE.

With the view of carrying the University Extension Work in Agriculture to the farmers, early in the spring a circular was prepared describing some simple tillage experiments with potatoes, corn, or sugar beets. Such decided results have been secured at the Station grounds by frequent and long continued tillage of the potato, that it was desired to learn if similar results might be secured by the farmers of the state, and with other crops as well as with potatoes. Correspondence was solicited with farmers who were willing to undertake experiments in co-operation with the Station. The Department of Agriculture at Washington supplied us with a quantity of sugar beet seed which was sent to farmers asking for it so long as the supply lasted.

The interest of the farmer seems to center in the sugar beets, very few undertaking tillage experiments with any other crop. Nor were many of them so much interested in the effect of different methods of cultivation upon the crop as they were to discover if, under the system of cultivation most common in the vicinity or most convenient to them during the season, their soils would produce a large yield of beets of sufficient richness to be profitably manufactured into sugar. There was, therefore, very little uniformity of methods in preparing the soil or cultivating the crop, and few attempted the comparison of different methods on the same field.

During August, members of the Station staff visited a large number of these experimental plats to note the conditions existing and advise the farmers in regard to their care. Again in October, representatives of the Station helped to harvest parts of many of them. The result of this work is fully set forth in Bulletin No. 143. The data relating to other work has not yet been tabulated for publication. Fig. 172 shows the postoffices at which sugar beet investigations have been made.

Horticultural Division (L. H. Bailey, Chief).

The horticultural enterprises which have been prosecuted under the auspices of the Nixon Bill during the past year have been of two general types, those conducted in various parts of the state, and those undertaken at the central Station at Ithaca. Work of a distinctly scientific nature can be prosecuted successfully only at the central Station where facilities are at hand and where the subjects are constantly under the eye of the investigator.

In field work in the state, the newer enterprises are work with fertilizers in strawberries in Oswego County, and experiments in celery culture on the onion lands of Orange County. The strawberry studies were begun by the late E. G. Lodeman, and they have now completed their second year. Some very satisfactory and practical results have been obtained, but it is desired to prosecute the work at least another year before reporting on it. Three years' study of the effects of fertilizers on treed nursery lands at Dansville has now been brought to a close with satisfactory conclusions. Experiments begun some time since in Chautauqua and Yates Counties in the fertilizing of vineyards are also going forward.

At Ithaca, experiments were made during the summer on new spraying materials and devices, and on the means to combat the San Josè scale, which, fortunately for experiments, colonized itself on the horticultural grounds. Some of the results of this work appear in Bulletin 144. Other work at Ithaca is proceeding along the following lines: Studies of Japanese plums, of methods of tilling and handling orchard lands, mushroom growing, strawberry forcing (a preliminary report published in Bulletin 134), experiments in floriculture, and studies of practicable means of combatting insects and fungi.

Chemical Division (G. C. Caldwell, Chief).

1. *Sugar Beet Investigations (By G. W. Cavanaugh).*

During the spring of 1897, this Station received from the U. S. Department of Agriculture, Washington, D. C., five hundred pounds of sugar beet seed. This seed was distributed in pound packages to five hundred farmers throughout the state, together with directions for planting the seed and cultivating the crop.

In order to obtain as correct information as possible relative to the conditions of soil, fertilizers, culture and atmosphere, a second circular was prepared and distributed during the latter part of September. This circular, besides containing directions for sampling the plats in such a way that estimates of the yield per acre might be determined, contained also a model and blank form for recording all data relative to tillage and fertilizing.

About four hundred of these circulars have been returned ; in general the data given indicated careful and painstaking work on the part of the experimenters. This mass of data is extremely valuable to the Station as furnishing a basis for future work on the subject of beet culture in New York. All this matter is contained in Bulletin 143.

Shortly after issuing the circular on sampling the beets, the samples for analysis began to arrive and continued to come in until January, 1898. They were on the whole carefully packed and showed evidence of a great interest in the subject on the part of the grower.

Besides analyzing some 475 samples sent in by growers throughout the state, about 125 samples grown on the Station grounds were examined. In addition to the analyses of the beets for their sugar content, studies were made of the food and fertilizing values of some of the by-products of the beets, i. e., the pulp, lime cake, molasses, as well as the crowns and leaves. It was possible to obtain for this purpose samples of the pulp, lime cake and molasses through the courtesy of the First New York Beet Sugar Company at Rome, N. Y.

2. *Field Work With Fertilizers* (*By A. L. Knisely*).

During the month of February, 1897, Bulletin No. 129 was issued giving hints and suggestions about the use of plant foods and explaining "How to Conduct Field Experiments With Fertilizers." This bulletin was accompanied by an application blank to be filled out and returned to the Station by any farmer in the state who wished to try a series of field experiments with fertilizers. The fertilizers necessary for a single series of experiments were then sent to each applicant, so far as the funds of the Station would allow, with directions for their application.

In all, four hundred and sixty applications were received and two hundred and three applicants were supplied with the fertilizers for the experimental work. The set of fertilizers sent to to each farmer consisted of:

4 sacks nitrate of soda containing 10 pounds each
2 " muriate of potash " 10 " "
2 " superphosphate " 20 " "
2 " each containing a mixture of 20 lbs., superphosphate and 10 lbs. muriate of potash.

Thus, each experimenter received 40 pounds nitrate of soda, 40 pounds muriate of potash and 80 pounds superphosphate. In all, 2,030 sacks were sent out, in sets of ten each, containing 8,120 pounds nitrate of soda, 8,120 pounds muriate of potash and 16,240 pounds superphosphate, making a total of 32,480 pounds.

Experiments were carried on in the following counties: Albany 1, Alleghany 3, Broome 4, Cattaraugus 5, Cayuga 4, Chautauqua 18, Chenango 11, Cortland 1, Delaware 1, Dutchess 2, Erie 2, Herkimer 2, Genesee 2, Jefferson 12, Lewis 1, Livingston 6, Madison 7, Monroe 5, Montgomery 5, Niagara 2, Oneida 11, Onondaga 13, Ontario 6, Orange 2, Orleans 2, Oswego 3, Otsego 2, Queens 1, Rensselaer 1, Saratoga 3, Schenectady 2, Schoharie 1, Schuyler 6, Seneca 4, St. Lawrence 3, Steuben 11, Sullivan 1, Tioga 7, Tompkins 8, Ulster 1, Washington 1, Wayne 13, Westchester 2, Wyoming 1, Yates 4, making a total of forty-five counties with two hundred and three experiments.

A Station representative spent most of the summer visiting the experimenters throughout the state, taking notes and some photographs of experimental plats; giving suggestions and explaining the work; finding out where mistakes and blunders had been made, and ascertaining just how the farmers received and took hold of this kind of work.

There were a few total failures; about half were doing the work fairly well and some twenty-five to thirty per cent were doing exceedingly well and had everything right. In all cases the farmers were very much interested in the work and said that this way of experimenting with fertilizers to learn what their land needed was what they had been wanting to find out. In some cases, where mistakes in applying the fertilizer had been made so that the experiment was a failure, the experimenter would say that if it were not too late he would purchase another set of fertilizers in order to carry on the work through the season.

The amount of benefit that the farmers will receive from these experiments cannot be measured by the success or failure of their experimental plats alone. Where the experiments were carried on properly the farmers were usually wide awake and energetic and had been in the habit of experimenting more or less.

In some other instances the experiments were almost total failures because the farmer had not been in the habit of experimenting, in fact did not know how to do it, or had no time for it. To such this work was a revelation. The probability is, that such farmers, even though their experimental plats this year were failures, have been helped proportionately more than those who had successful experimental plats and had been accustomed to experimenting.

The experiments have been all the more beneficial and instructive because the farmers have done the work themselves and, therefore, were much more interested in it than they would have been had it been done by the Station and the results then read by the farmers.

In September, a circular concerning field experiments with fertilizers was sent to each experimenter, giving directions for harvesting the crop on each experimental plat and for making out and sending the reports to the Station. Up to the present writing, nearly all the reports have been received and, on the whole, they are very satisfactory, considering that this is the first time that the experimenters have made such reports.

In the near future we expect to publish the results of the summer's work with fertilizers, so that all can see what the farmer can do in carrying on experimental work.

Entomological Division (J. H. Comstock, Chief).

BY M. V. SLINGERLAND.

The final results from our extensive experiment against the peach borer, extending over a period of three years, were ascertained during the past summer. This investigation has revealed some striking and valuable facts which will add much definite data to our knowledge of how to fight this serious peach pest. We are now collating and digesting the details of this work which have accumulated during the past three years, and we hope to get the conclusions ready for publication during the coming year.

The above extensive experiment on 450 trees, and the increasing correspondence of the Division have occupied a large share of our attention since last spring. The funds placed at our disposal by the so-called "Nixon Bill" have enabled us to get in closer touch with New York fruit-growers and general farmers, and this has resulted in a marked increase in the quantity and quality of our correspondence. The leaven of the educational features of the work is undoubtedly beginning to work, for our queries are becoming more and more definite and intelligent. We consider our correspondence one of the most valuable and important features of the work of this Division, for we are thus often enabled to reach special and urgent cases quickly.

In 1896, an insect known as the quince curculio was so destructive in some localities as to lead growers of this fruit to seriously consider the advisability of cutting down their orchards. Early in 1897, we began a critical study of the habits of this pest, and continued our observations during the season, or until we had learned its life-story and had become familiar with its habits. Our observations show that there is little, if any, possibility of poisoning the insect with an arsenical spray, and that early cultivation will have but little effect upon it, thus disproving two of the so-called "remedies" by which it has been supposed that the pest could be reached. Our study of its life revealed some striking variations from its habits of the preceding year. By carefully watching the insect in our cages at the insectary, we were enabled to give several large quince growers warning that the pest was appearing in alarming numbers nearly two months later than its schedule time of the preceding year. By following our suggestions, one extensive grower of this fruit, whose crop was nearly an entire failure in 1896, due principally to the work of this insect, was enabled to harvest the finest crop of quinces he ever had. A few careful observations in our cages at the insectary upon this single insect pest thus resulted in the saving of hundreds of dollars worth of fruit in a single orchard. The result of our study of this quince curculio will be ready for publication as soon as funds are available.

For several years, hundreds of acres of apple orchards in Western New York have been annually stripped of their foliage by canker-worms. The Station has clearly demonstrated Bulletin No. 101, that these pests can be controlled by thorough work with a poison spray, and yet their ravages go on unchecked in many localities. We had supposed that most, if not all, of the damage was being done by the spring canker-worm, but in November last we received definite information from one locality that at least three other similar insects was then ascending the trees and laying their eggs. One of these insects is new to us and we have not yet learned its name. We have obtained good pictures of nearly all of the forms, and have arranged to go into the field and make a critical study of all of the four kinds of canker-worms which are apparently responsible for the destruction being wrought in Western New York orchards.

Past experience shows that it is impossible to predict what insect pest will require attention during the coming year. Whether the tent-caterpillars, plant-lice, the pear psyllas, or any of the other insects which were so numerous in 1897 will again be as destructive in 1898 or not, we do not care to hazard a guess.

Dairy Bacteriology (*V. A. Moore, Chief*).

BY A. R. WARD.

It has been demonstrated that many of the difficulties encountered by our dairymen in obtaining desirable butter and cheese are attributable to bacterial agencies. The varieties of their troubles are numerous and their effect is often disastrous to the prosperity of the creameries and cheese factories where they occur. What are the causes of the bad butter and poor cheese, and how can these causes be removed, are questions which are constantly being asked and which cannot, in most cases at least, be answered satisfactorily until the fundamental principles underlying their causes are carefully worked out and formulated.

During the past summer, by the aid furnished by the New York State Veterinary College, we have started work on certain of these highly practical problems. The results are not yet ready for publication, but when the work is completed it will throw much light upon the relation existing between the bacteria of the immediate surroundings of the cows and of those in the flora of the milk ducts themselves and the gassy curds, bad flavors and taints of the milk products. There are in progress important experiments looking to a practical method for disinfecting the milk passages of those cows which harbor undesirable species of bacteria, and also investigations for determining the character of the bacteria in the milk ducts of cows kept in clean and properly ventilated stables. It has already been found by others, and verified by us, that the condition of the environment of the cows has much to do with the character of the bacteria necessarily present in the milk. These in turn have much to do with the quality of the milk products.

Unfortunately, we have but recently been able to start this work, and are now in temporary quarters. It is hoped that in the near future we may have a well equipped laboratory and funds sufficient to carry on these investigations to the extent their economic importance demands.

Botanical Division. (*G. F. Atkinson, Chief*).

BY B. M. DUGGAR.

Investigations are in progress, which already have extended over several years, upon the fungus diseases of forest trees, and of timber. Material is nearly ready for a bulletin on some diseases of the timber spruce, and on the effect of wind on trees weakened by the action of fungi. Researches are also being prosecuted upon the embryology of the conifers, and upon the development and structure of seedling trees.

A bulletin on Some Important Pear Diseases has been published, This included, especially, notes upon the leaf-spot of pear, another injurious leaf fungus, probably often confused with leaf blight. Spraying experiments showed that Bordeaux mixture may be effectually used to prevent this disease. Leaf-blight, scab, and pear blight are also discussed. Other more obscure and less injurious pear fungi are under study.

The black mold of peach and apricot, and the shot-hole fungus of the peach, apricot and plum have received some attention, but the work is incomplete.

Field spraying experiments for the prevention of the late blight of celery were conducted at the celery gardens of South Lima. While this blight was less injurious during the past season, it was demonstrated that weak Bordeaux mixture could be used until within about five weeks of bleaching, and that as a fungicide for celery blight the Bordeaux is superior to the ammoniacal copper carbonate. It is well, however, to use the latter fungicide if spraying must be done within a month of bleaching.

The "damping off" fungi of lettuce and other plants grown under glass have been studied with special reference to the conditions favoring the disease. An attempt is being made to follow out the life histories of the fungi concerned. This work is still in progress.

A rot of greenhouse tomatoes has received considerable attention, and while no fungus has been found associated with it, experiments are being made to ascertain, if possible, the conditions which may induce it.

Investigations upon a mold growth occurring upon the parchment paper lining and upon the wood of butter tubs have determined the conditions of growth of the fungus. Care in the selection of tubs made from well seasoned heart wood, the storing of tubs in a dry place, and the use of the best parchment paper will probably reduce the liability of mold. However, experiments indicate that the use of one per cent formalin solution, or a very weak solution of copper sulphate upon the parchment paper will prevent the growth of mold.

An effort is being made to look more carefully into some of our bacterial diseases of plants, and to study those which may be due to such organisms.

PART II.

EDUCATIONAL WORK.

It was decided at the first meeting of the Faculty of Agriculture to emphasize the educational work, since the Federal Experiment Station, a department of the College of Agrculture, was able to carry on many investigations, especially those which, of necessity, must extend through considerable periods of time and which require ample and permanent laboratories, equipment and investigators, while most of the work contemplated under Chapter 128 could best be carried on away from the college.

The problem of how to successfully introduce into the schools of the state a study of the fundamental principles which govern the soil, the plant and the animal, or the study of Agriculture, has been considered most carefully by many distinguished educators. This subject was long and carefully considered by the Faculty of Agriculture before entering upon the work. The leaflets on Nature-Study which were already issued had been so kindly received and so fully appreciated that it was decided to issue others and to employ trained teachers to visit the schools and to attend Teachers' Institutes for the purpose of explaining how the subject-matter of the leaflets, as well as other similar subjects, might be used as texts by the teacher, while the illustrations could not help but be useful to the teachers of classes in drawing. It was hoped, too, that after the teacher had given instruction on some subject intimately connected with natural objects which attract the attention of the pupil, the object having been used for a drawing in the class room, the description of such object would form a most interesting subject for compositions, which are now required in most departments of the public schools. By correlating with composition and drawing work, the objection of an added study was removed.

It is believed that a study of the more common and familiar objects of nature leads directly to a better understanding of those laws and phenomena which are the very foundation of improved agriculture. In the hands of the skillful teacher the leaflets may be used to impart valuable lessons in nature history and in the conservation of energy as applied to rural affairs and may, in some cases, serve to interest teacher and pupil in the economics of agriculture. Briefly stated, it is hoped that such instruction will lead logically and naturally to a greater love for rural affairs and a more rational understanding of them among the old and young both in city and in country.

Eight leaflets in all have been published, electrotyped and republished on the following subjects:

No. 1.	"How a Squash Plant Gets Out of the Seed."	Four Editions.
No. 2.	"How a Candle Burns."	Three "
No. 3.	"Four Apple Twigs."	Five "
No. 4.	"A Children's Garden."	Six "
No. 5.	"Some Tent-Makers."	Four "
No. 6.	"What is Nature-Study."	Four "
No. 7.	"Hints on Making Collections of Insects."	Two "
No. 8.	"The Leaves and Acorns of Our Common Oaks."	Two "

The demand for these leaflets is so great that other editions will be required in the near future. The work in Nature-Study has passed the experimental stage; the demand for it is far beyond our facilities for carrying it forward.

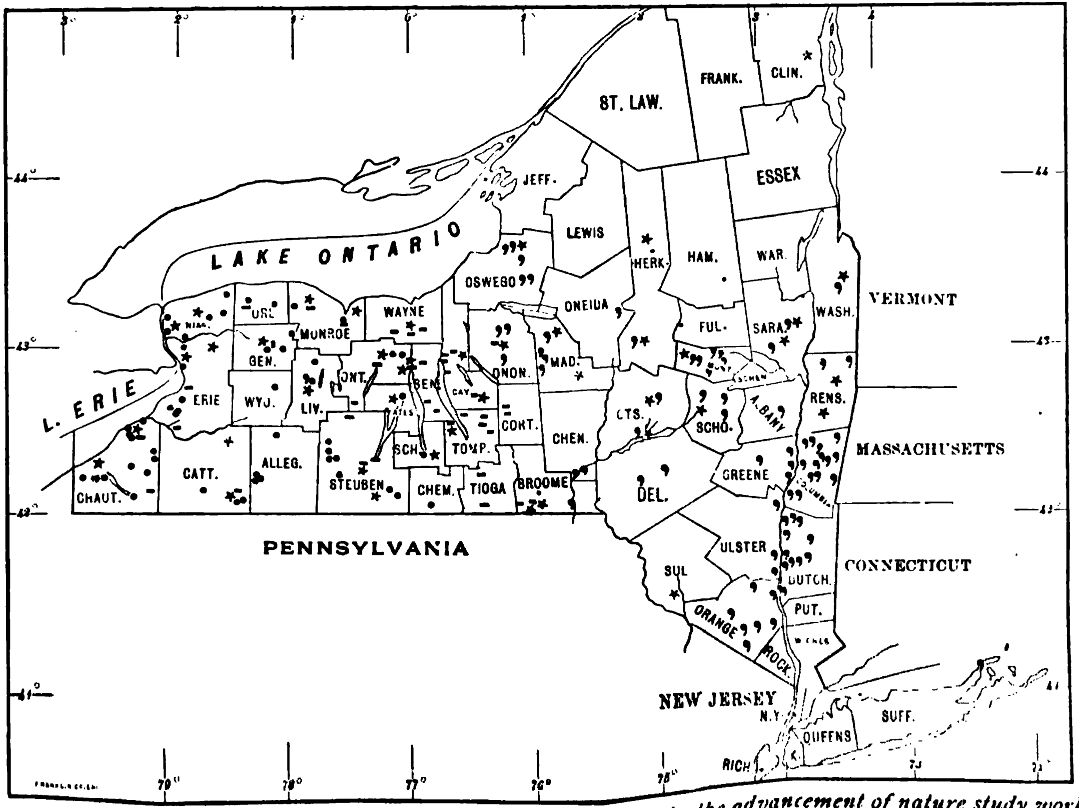
This educational work in agriculture divides itself naturally into six divisions:

Nature-Study,
Schools of Agriculture and Horticulture,
Dairy Instruction,
Lectures on special subjects, such as the Sugar Beet Industry,
A course of reading and instruction for farmers,
Publications.

There are many principles of agriculture which are well understood by the scientist but which are not familiar to the farmer. It is proposed to secure the co-operation of progressive agriculturists in the endeavor to learn how best to fit these principles into practice.

It is impossible to sharply separate these various activities, as one often overlaps the other. Suffice it to say that more than seven hundred lessons and lectures have been given throughout the state by persons selected on account of their special fitness for the work in hand.

Thirty thousand teachers are enrolled on our lists and have



174.—*Showing where meetings have been held and schools visited in the advancement of nature study work.*

received leaflets, and many have attended the lectures explaining the methods of presenting Nature-study work in the schools. Sixteen thousand school children have received those leaflets which are especially adapted to their needs. Two thousand five hundred young farmers are enrolled in the Agricultural Reading Course. These are assisted from time to time by means of printed circulars which give directions and assistance to the farmer in carrying on his studies at home. From time to time question papers are sent out for the purpose of giving opportunity to the farmer to make known his needs that they may be more fully understood and met. The location of nature-study centers is shown in Fig. 174.

Mr. A. C. True, Director of Office of Experiment Stations, Washington, D. C., suggested that the members of the instructing corps of the University give a course of lectures on Agriculture in the schools of Ithaca with the view of determining whether such instruction could be fitted into the present curriculum without adding seriously to the work already required. The Superintendent of the City schools and the Superior of the Parochial school entered into the scheme most heartily. Their opinion of this work is set forth in the following communications:

BOARD OF EDUCATION.

ROGER B. WILLIAMS, *President.*
H. W. FOSTER, *Superintendent of Schools.*
OFFICE—32, 33, SAVINGS BANK BUILDING.

ITHACA, N. Y., Jan. 28, 1898.

PROF. I. P. ROBERTS,

Dear Sir:—On behalf of the A room of the Grammar School, I wish to thank you and the professors whom you sent for the lectures and demonstrations which were given before the pupils of that room during the past term. I was present but very little myself, but the teacher reports a very great interest on the part of the pupils. Every one of the lectures was used as a basis for composition work. It seemed to us that the English work resulting was unusually good and that there was a decided improvement, a part of which at least we attributed to the very great interest of the pupils and their desire to give expression from a mind full of the subject. It appears to me that full and free use of language must necessarily arise from an abundance of thought pressing for expression. A full flowing stream implies an overflowing reservoir.

This work is not to be classed under the head of science or nature study purely, wherein the method is to employ the child's powers of observation and judgment. Its purpose was rather to arouse an interest in the science of agriculture. These city pupils will always have hereafter the highest respect for the work and life of a farmer, and many of them without doubt will observe and think intelligently upon the methods of agriculture. I have no doubt that some will put into practice much that they have learned. It is conclusively proved that agriculture may be made an extremely interesting and valuable subject of study in all schools. Yours very truly,

H. W. FOSTER, Supt.

CHURCH OF THE
IMMACULATE CONCEPTION,
REV. A. J. EVANS, *Rector.*

ITHACA, N. Y., Jan. 31, 1898.

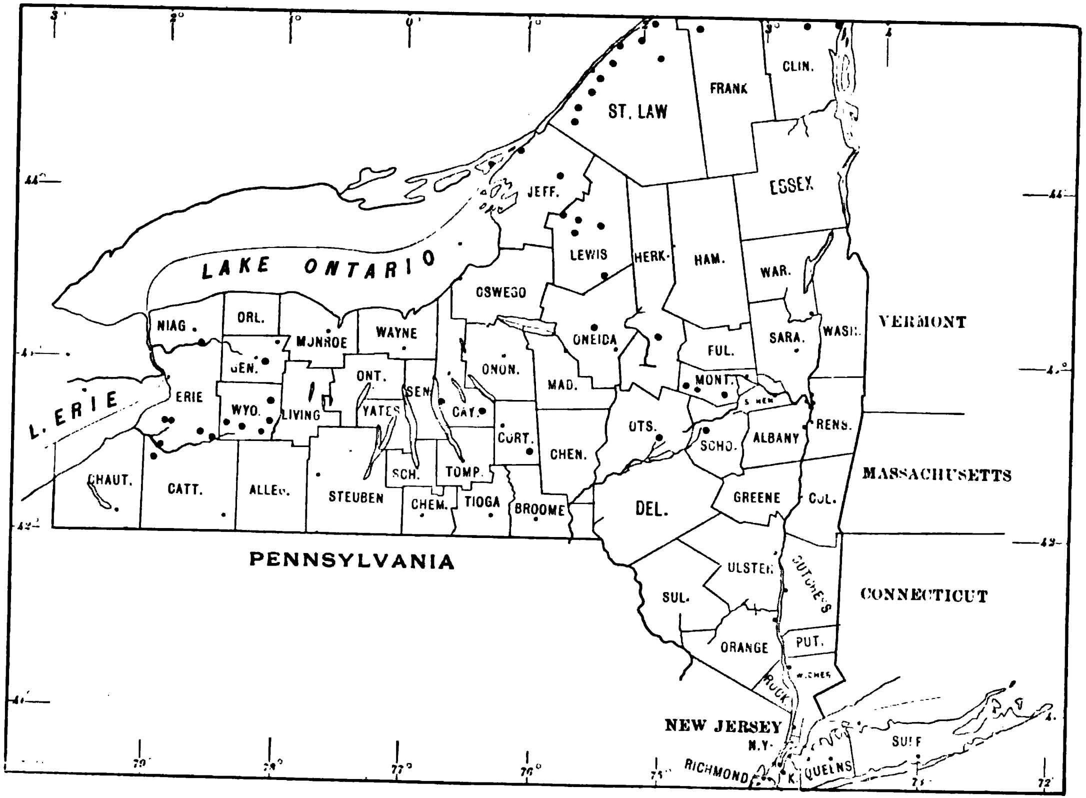
PROF. I. P. ROBERTS,

Dear Sir:—I have attended three or four of the lectures on "Nature Study" delivered by you and your associates at our Parochial school. Judging by the good attention shown by our pupils, and the earnest manner in which they answered the questions put to them, I am convinced that the lectures were pleasing and instructive.

The work in which you are engaged cannot fail to be productive of much good in our schools, because the pupils are made familiar with those things which will be of much benefit to them in after life. I sincerely trust that you will be enabled to continue the lectures, not only this year, but permanantly.

Thanking you for the many past favors, I am,

Yours sincerely, A. J. EVANS.



173.—*Showing points where dairy schools were held.*

It is believed that the benefits derived from carrying the experimental work beyond the limits of the Station grounds are very great. First, the data obtained are valuable. In some cases they are much more valuable than could possibly be obtained from experiments conducted at the Station. In corroboration of this statement, reference is made to the bulletin on sugar beets already mentioned. Second, the Station is brought into closer touch with the farmers. Meeting them on their own farms, the Station workers become better acquainted with their peculiar surroundings and needs, and can offer more appropriate assistance than they otherwise could do. On the other hand, the farmers learn better how the Station can help them and how to avail themselves of that help. Third, the experiments serve as object lessons to the farmers. As such they impress themselves upon a large class of farmers that would give little heed to a printed description of experiments conducted at the Station.. Fourth, the experiments have a high educational value for the farmers performing them. Perhaps, at the present time, this is the most important consideration. There are many questions affected by soil and climate that must be decided for each locality individually, and the greatest hindrance is the want of trained experimenters to take up the work. It is hoped and believed that we shall find in various localities in the state intelligent and public spirited farmers who, for the benefits to be derived by themselves and their fellows, will be willing to co-operate with the Station in this work.

DAIRY HUSBANDRY.

Observations in the dairy districts led to the conclusion that this branch of Agriculture needed assistance. The theory of making butter and cheese is fairly well understood but the art, in many cases, was found to be lamentably wanting. To bridge over this gap between science and art, two expert dairymen were employed during the summer, men who not only knew much of the science but of the art of dairy husbandry as well. These men went from factory to factory, called a few dairymen together and gave valuable instruction by first teaching the leading principles and then by practically applying them, thus showing how art and science in dairy husbandry could be joined. Many difficult problems appear in the factories during the midsummer season; these can only be solved by a trained dairyman at the factory. Incidentally, these instructors did much valuable service by calling attention to untidy surroundings and irrational treatment of cattle. The location of dairy schools is shown in Fig. 173.

SCHOOLS OF AGRICULTURE AND HORTICULTURE.

The effort to organize schools of general Agriculture, Horticulture and Dairy Husbandry has not, in all cases, been successful, as there were often a great diversity of specialized agricultural activities represented by the persons in attendance, each calling for help. Wherever practicable, it has been the aim to secure the attendance of those persons who were engaged in like specialized activities. In such cases it was not difficult to organize schools and carry on the work consecutively and logically on restricted lines.

The instructors in this line have also given attention to the pupils in the country schools, and while it has been possible to reach and teach but a comparatively few pupils in the "red school-house," we are led to believe that this work has been of great value since it touches agriculture at its fountain head.

It is fully realized that it will be impossible for us to reach all the school children directly, but it is believed that all can be reached as soon as the public school teachers of the state have mastered the leading fundamental principles which govern the soil and plant and animal life, and have come to love the study of Nature in any or all of her varied forms.

Rural life gives unexcelled opportunities for securing fresh living objects for illustration. All that is now lacking is a teacher trained to see the beauties and uses of the common objects which surround the pupils of village and city alike. How may all of the teachers secure such an education in the particular lines referred to above is a problem which is receiving careful consideration. Something has already been done in this direction and the results reached lead to the conclusion that much more should be done and that the wards of the state, the children in both city and country, have a right to demand that they have opportunity for securing some knowledge of and acquaintance with the natural objects with which they are surrounded and with which they will have much to do in after life.

SPECIAL LECTURES.

There has been a demand for information on many subjects, but especially on the subjects of sugar beet and potato culture. This demand has been met so far as possible by sending out from time to time members of the staff who are especially qualified to give the information desired. This branch of educational work has been most satisfactory, the meetings being well attended and the interest shown unusual.

A valuable feature of many of the meetings was the demonstration of how certain scientific tests relative to soil might be made by the farmers. In this connection the test for acid in soils by the use of litmus paper may be mentioned. Results from this work show that sour soils are quite prevalent and promise a good field for investigation.

FARMER'S READING COURSE..

Last year an attempt was made to establish a Farmer's Home Reading Course, but it was not fully organized because of press of work in other directions. At the present time three thousand young farmers are registered with us and a circular containing sixteen pages entitled "Farmer's Reading Lesson, Texture of Soil and Conservation of Moisture" has been issued with the view to giving help, direction and definiteness to the work. Accompanying this circular is another one of eight pages which contains twenty-seven questions, the aim being to draw out the reader and awaken interest. It is believed that the young farmer already possesses much valuable information, which, if drawn out and supplemented, would be mutually interesting and valuable.

It is our plan to arrange a course of topics having a logical connection and divided into stages of advancement. The study of these topics can be carried on at the farmer's home with a review by correspondence, after the Chautauqua reading course plan. If neighbors can form a circle for discussing the subjects under consideration, interest and benefit will be very much enhanced.

The effort has been to give such instruction as will not only promote "agricultural knowledge" throughout the state but to get parents and pupils in sympathy with the fundamental object of our endeavors, which in all of this work has been to train the intellect, the eye and the judgment with the view to educating the farmer to better methods.

The educational work which had already been done prior to April, 1897, by Prof. L. H. Bailey, and his associates in horticulture in the western part of the state, made it possible to secure the coöperation of more than three hundred farmers in the investigations in sugar beet culture, and two hundred three farmers in the experiment with fertilizers. The time has come when the help of the farmers must be secured if valuable investigations are to be conducted which shall be applicable to varied conditions. Climate, soil, environment and needs are so varied in the state that comparatively little help can be given unless the investigations can be conducted in the locality where the help is needed.

It follows then that many trained farmers and even farmers' boys and girls must be enlisted in the work. We now have in this state a considerable number in the rural districts who are able and quick to see and to comprehend dangers which threaten and to report them. They are also ready at all times to conduct plat investigations free of cost at their own farms if direction and help can be given by the Station. Many investigations suited to local needs will be undertaken the next season by reason of the instruction which has been given. So well assured are we of the twofold benefit of the educational work which has been carried on that it is proposed to extend it another year.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses, 26 pp.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf-Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N. Y., 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western N. Y., 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in N. Y., 24 pp.
87 Dwarf Lima Beans, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
98 Cherries, 34 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western, N.Y. 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinions of the Japanese Plums, 30 pp.
107 Wireworms and the Bud Moth, 34 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
116 Dwarf Apples, 31 pp.
117 Fruit Brevities, 50 pp.
119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery, 30 pp.
122 Second Report upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York., 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138 Studies and Illustrations of Mushrooms; I, 32 pp.
139 Third Report upon Japanese Plums, 15 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a Cause of Death Among Swill-Fed Pigs, 12 pp.
142 The Codling-Moth, 69 pp.
143 Sugar Beet Investigations, 88 pp.
144 Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Report of Progress, 20 pp.

ail list

Bulletin 147. **April, 1898.**

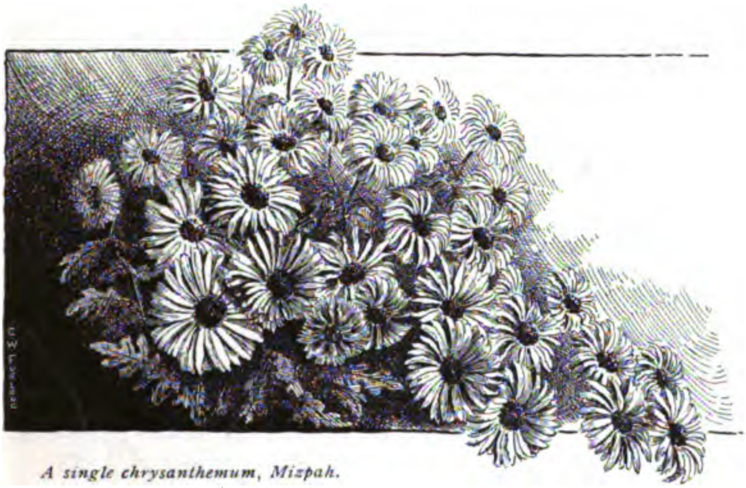
Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

HORTICULTURAL DIVISION.

FOURTH REPORT UPON

CHRYSANTHEMUMS.



A single chrysanthemum, Mizpah.

By WILHELM MILLER.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

ORGANIZATION.

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B. M. Duggar,	Botany.

OFFICERS OF THE STATION.

I. P. Roberts,	Director.
E. L. Williams,	Treasurer.
Edward A. Butler,	Clerk.

In pursuance of the provisions of Chapter 67 of the Laws of 1898, several persons have been appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work require.

See Bulletin 146, Report of Progress of work done under Chapter 128 of the Laws of 1897.

Office of the Director, 20 Morrill Hall.

The regular bulletins of the Station are sent free to all who request them.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.

CORNELL UNIVERSITY, March 21, 1898.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The popular interest in chrysanthemums continues to be unabated. The chrysanthemum fills a season which is occupied by no other important flower, and it presents the most astonishing ranges of form, color and behavior. In addition to all this, the plant is easily grown and it responds quickly to all the little modifications of treatment which the plant-lover habitually bestows upon his plants. For these reasons, the chrysanthemum must continue to be popular and to demand the attention of experimenters.

We desire to still further popularize the plant among the amateurs and especially with those who live in the country. We have therefore given general hints upon the cultivation of the plant when glass houses cannot be had.

On the other hand, we desire to aid the professional florist; and for him we have grown the novelties, have begun experiments with fertilizers (which we shall continue), have studied some of the problems associated with variations in color, and have now made a full review of the vexed questions involved in the selection of crown and terminal buds.

This report, therefore, considers the following matters:

I. The economic status of the chrysanthemum. Pages 659, 660.

II. Suggestions on growing chrysanthemums at home. Pages 660 to 668.

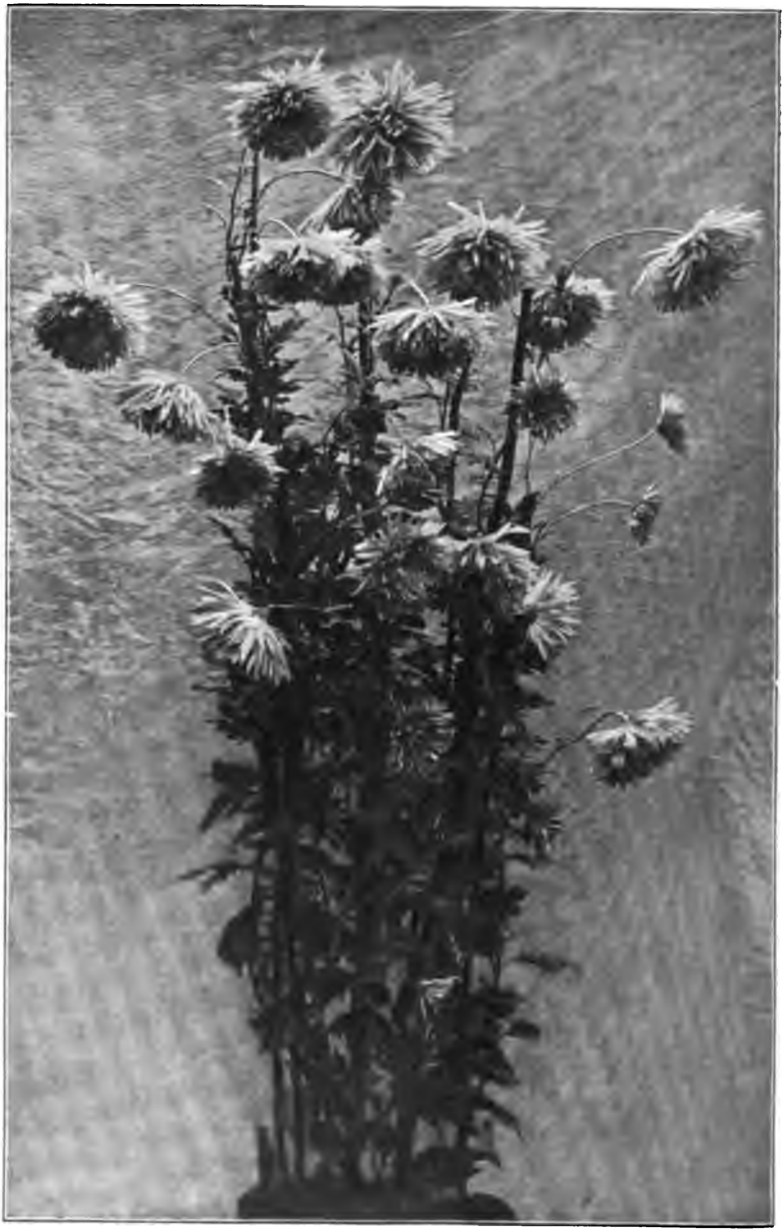
III. Controlling the color of chrysanthemums. Pages 668 to 672.

IV. Crown and terminal buds. Pages 673 to 684.

V. The Cornell varieties of 1897. Pages 685 to 689.

VI. Summary. Page 689.

I. P. ROBERTS,
Director.



174. *An amateur's ideal. A mass-effect with many flowers of different ages and sizes. Same variety as in Fig. 175.*

I. THE ECONOMIC STATUS OF THE CHRYSANTHEMUM.

The chrysanthemum industry in New York State probably involves more capital than the growing of peaches. When the chrysanthemum craze began in America in 1888, there were loud complaints from those florists who thought that there would be no great permanent popularity after the first fever was passed. At first, the chrysanthemum seriously infringed for six weeks upon the year-round favorites, the rose, carnation, and violet, but it must now be considered one of the four staples of greenhouse floriculture. We have more chrysanthemums now than ever, but the feverish element is nearly gone. The times of universally excessive prices are forever past, the readjustment to a final acceptance of this new-comer's permanent place is nearly made, and the chrysanthemum has become distinctly a flower of the people.

What, then, is the permanent place of the chrysanthemum? Doubtless its mission is to fill the dull interval between the middle of October and the last of November. The skilled amateur, it is true, may prolong the season by early flowers out-of-doors and by late ones in the greenhouse, but it is at a cost of time, money and skill that the people cannot give. He may even have large flowers in every month of the year, at a large price, but the true chrysanthemum niche is a period of about six weeks, and the people would not want chrysanthemums the year round even if they could have them.

The people, then, buy the flowers; they do not raise the plants themselves. The only possible objection to the Japanese chrysanthemums is that the people of the north cannot cultivate them in their gardens, that is, they cannot produce large, exhibition flowers, or even typical ones, in satisfactory quantities out-of-doors. Until twenty-five years ago this would have been a fatal objection. Never until the development of the peculiar forcing-house industry of America, the commercializing of floriculture on a vast national scale, was it possible for a flower grown almost exclusively by the florists, and under glass, to win its way into the hearts of the masses. It is the greater general use of cut-flowers that makes American floriculture unique. The popular demand for long-stemmed flowers, and for some favorites in every month of the year, has conspicuously changed the methods of cultivation of chrysanthemums, roses and violets and has given to the world a distinctly American type of carnations. Americans buy cut-flowers, keep them in vases as long as they are thoroughly satisfactory, and are very sensitive to the delights of arrangement for form and color effects. The keeping qualities of chrysanthemums are extraordinary, and this happy circumstance is one reason why this greenhouse flower has so won its way into the hearts of the masses.

Nevertheless, the cry is sometimes raised that the chrysanthemum is a "rich man's flower." Moreover, the love of the *blossom* is only the beginning of nature-wisdom. Until there is developed a feeling for *the plant*, there is no deep sympathy with, or real insight into the meaning and mystery of nature. The best relation with plants is the living with them, the appreciation of every stage of their life cycle. Ten cents will buy a magnificent flower, but no one may own a chrysanthemum in the highest sense without a year's comradeship with the plant. You must produce it—evolve it, as it were, from your own understanding of life.

II. SUGGESTIONS ON GROWING CHRYSANTHEMUMS AT HOME.

It is not true that the farmer's wife may not have a few fine chrysanthemums. She may have them in her garden for the price the least part of which is paid in money, but they will give the highest pleasure when they blossom indoors during November. They cannot be raised as easily as a geranium (which in this single respect is the ideal plant for the window garden) but they can be grown in the home by all who really love to care for plants. People are always asking (and I hope they always will ask) just how to do it. The horticultural journals

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*Portions of the following have been published in the *American Agriculturist*, with illustrations.

answer, the daily newspapers tell the story during show time, and a brief account was given in Bulletin 136 from this station. But it is discouraging to be referred to back numbers, and a more extended account is needed in a separate form.

The very first requisite of success is to cherish an ideal! Some one of at least four different objects must be clearly conceived at the start and kept in view till the very end.

1. Do you want a few large flowers such as you see at the shows? Then you can have only one stem in a flower pot and only one flower on that stem (Fig. 175), and you must have pots of various sizes up to six or eight inches in diameter at the rim. Pinch off the young shoots as soon as they show themselves, so that the plant can never branch. If you are successful you will have the beauty of an individual object. It will be a wonderful thing and may not fit in with anything else, but will demand attention for itself alone. Remember that size alone is vulgar, and that the delicate and fanciful may be made gross and characterless by over-feeding.

2. Do you wish enough size of flower so that you can recognize the variety, and are you willing to sacrifice somewhat in point of numbers? Then you had better aim to produce about four flowers to every plant, each flower six inches in diameter, and with only one flower on each branch. These branches should be as long as possible and therefore you should pinch out the central shoot of the young plant when it is five or six inches above the soil and make it branch. Teach it to cherish a high ideal—the ideal of four fine flowers, each at the top of a long branch. On the whole, this is the best method for the home window, and with practice, from three to six large characteristic flowers may be grown in a six-inch flower pot.

3. Would you like a handsome, symmetrical, bushy plant with twenty or more flowers? Don't try it expecting great success with little care. The flowers will be small, sometimes partially developed, and so lacking in character that you can scarcely ever tell the variety. It also takes too much tying and training and disbudding, and the result is more or less artifical and has no artistic value except for mass effect. Skilled gardeners can do it but it costs more time than most people can give. The plants

must be started early, fed with great care and must be shifted successively from small-sized flower pots to those of eight to ten inches at least. The English gardeners are far more skillful than we in such work and it is not uncommon to see pictures of plants with from fifty to three hundred large well-formed blooms upon them. But specimen plants and standards*, are far less frequent proportionately in America. It is partly because of higher-priced labor and partly because we do not like them so well as Europeans do. Figures 174 and 179 illustrate two types of bush plant that may be raised at home in a six-inch pot.

4. Do you want a few chrysanthemums in your window with the least trouble and expense? Then you had better aim either at ideal 2, or else have your own way and make the best of what you get. Most people will not repot their plants in successively larger sizes, and they are afraid to disbud or do not believe in it. In such cases they can only hope for a goodly number of flowers that look well enough at a distance and make a brave show of color, but the beauty of form is largely lost. Size and form are the products of disbudding. Everybody has some color sense, but the conscious pleasure in form is a later development. However, it ought to be said that imperfectly blown flowers of chrysanthemums often have a beauty in mass effect. They are rarely painful, as is a partially blown dahlia. This is probably because the fully developed flower in one case is loose and free, while in the other it is often set and formal.

Whatever ideal is chosen, the best way to begin, in general, is to buy a young plant of the florist. Young plants of any size from two to twelve inches in height can usually be had any time from March to July 1. Trust to the florist for the variety, unless you have made a memorandum at the flower-show or elsewhere of the desirable varieties, or unless you wish to reproduce some of the effects pictured in Cornell Experiment Station Bulletins 91, 112, 136, or 147. In general, dwarf, short-jointed varieties are best for the window-garden. Probably most people will prefer to buy their plants in May, or early June, plant them outdoors in boxes and remove them bodily indoors at the approach of frost. It is possible to plant them in the open ground for the summer, take them up carefully in the autumn, and then put them into flower-pots. The box method, however, avoids the shock of transplanting. It is not necessary to buy flower-pots of graded sizes. Old soap boxes will do very well, although not handsome or as good as pots; but tin cans are too small, and transplanting from them is practically impossible. Some hints on the drainage and watering of plants in general are given in Bulletin 136, and the rest is usually easy.

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*A "standard" is a plant with many branches at the top of a single, stout, self-supporting stem. The term is not confined to chrysanthemums.

175. *A florist's ideal. One large flower on a long stem that will sell, and will bear railway shipment.* (*Florists' Exchange, Dec. 5, 1896.*) *See Fig. 174.*

The growing of chrysanthemums out-of-doors all the year round for the production of large flowers is too complicated and special a topic for the present. Those Americans who are determined to succeed at such work should read in *Garden and Forest*, 1 : 522 (1888) and elsewhere, the experience of J. N. Gerard, of Elizabeth, N. J., an experience that richly deserves separate publication.

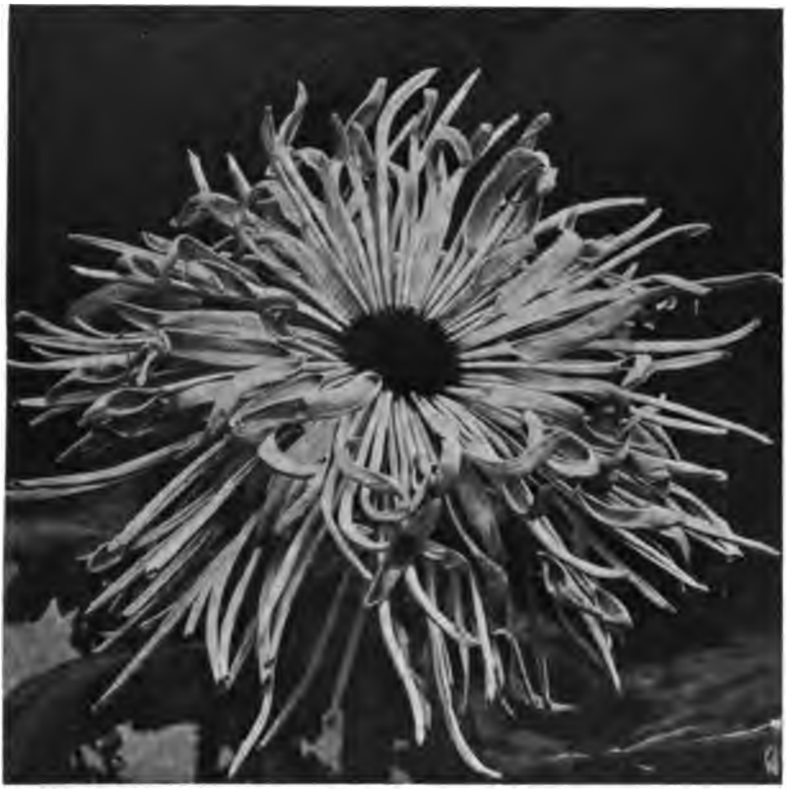
The amateur and the florist.—If we had to depend upon the commercial florists for the preservation of all varieties, many of the finer creations that appeal to the fancy would doubtless be lost to the world. The florist cannot always grow what he likes.

He must follow the fashions, he must keep what the people demand, and he must have the kinds that last well and ship well. His business is chiefly with cut-flowers. The amateur is chiefly concerned with plants. It is highly unfair to reproach the florist with want of taste. The mixed bouquet, with its tin-foil, is passing away. Dried grasses and dyed immortelles are still in demand, but the florist does not create this demand. Indeed, the fashions in the world of dress and in the world of flowers have fundamental differences in their origin. Whoever starts them, the florist does not, and the general taste of the American florist is higher to-day than ever before.

The amateur class, however, is the great conserving element. The commercial motive being absent, the amateur can keep a variety whose flower he likes even if the plant has a poor habit. Not poor taste but practical reasons compel florists to discard some of the finest flowers. Hundreds of varieties of chrysanthemums are discarded because they are too tall, or require too much staking or disbudding. Others cannot be planted close enough together in the modern method for cut flowers where the total salable product of a whole plant is one unbranched stem and one flower. The amateur can afford to keep varieties with bare or drooping necks if he likes the flowers. He may be willing to stake and tie such plants as are illustrated by Fig. 174, and perhaps he may like the droop of the stems so much that he does not mind the stakes and the strings. Perhaps he likes the great hollow cone leading up mysteriously into the warm golden heart of the flower. But the florist cannot sell such things. Fig. 175 shows a flower of the same variety which is presumably grown on a single stem. The flower in Fig. 175 is larger, has no yellow disc, will ship better, last longer when cut, and it will sell. Fig. 176 represents another amateur's ideal, and so do the loose, free, and fantastic forms figured in Bulletin 112. As a rule, only compact and globular chrysanthemums can be depended on to stand a long railway journey ; therefore the florist must, perforce, adhere to these forms if he would make a living.

As this may be the last bulletin of this station in which varieties are prominently mentioned, it is worth while to make a strong appeal to the amateurs of this country to keep a firm hold upon all the main types, and especially to retain the sorts whose delicate flowers will not bear transportation.

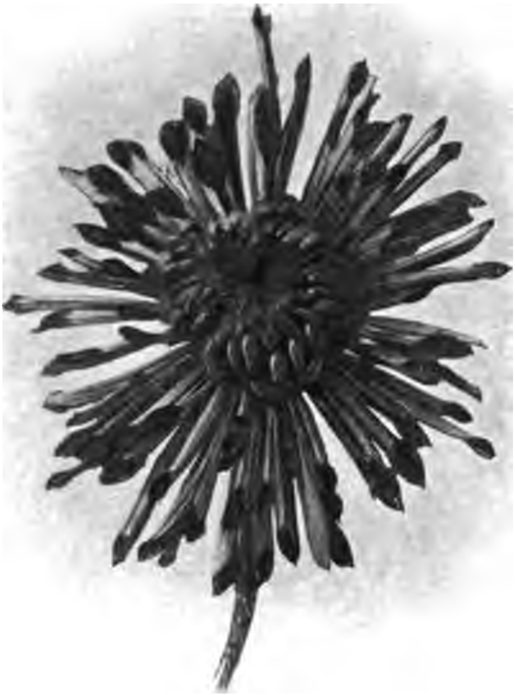
We are behind the English in the appreciation of all but two or three of the eleven "sections" recognized by the National Chrysanthemum Society. (For a specimen of the "single section" see title-page.) There are certain classes and certain ideals that are peculiar to the amateur and the artist. Figures 177 and 178 illustrate one of these classes. They show the same variety, but one would never think it from seeing only the two stages. The fascination of watching the daily changes of



176. *Another type that the amateur likes.* (*Variety, A. H. Wood.*)

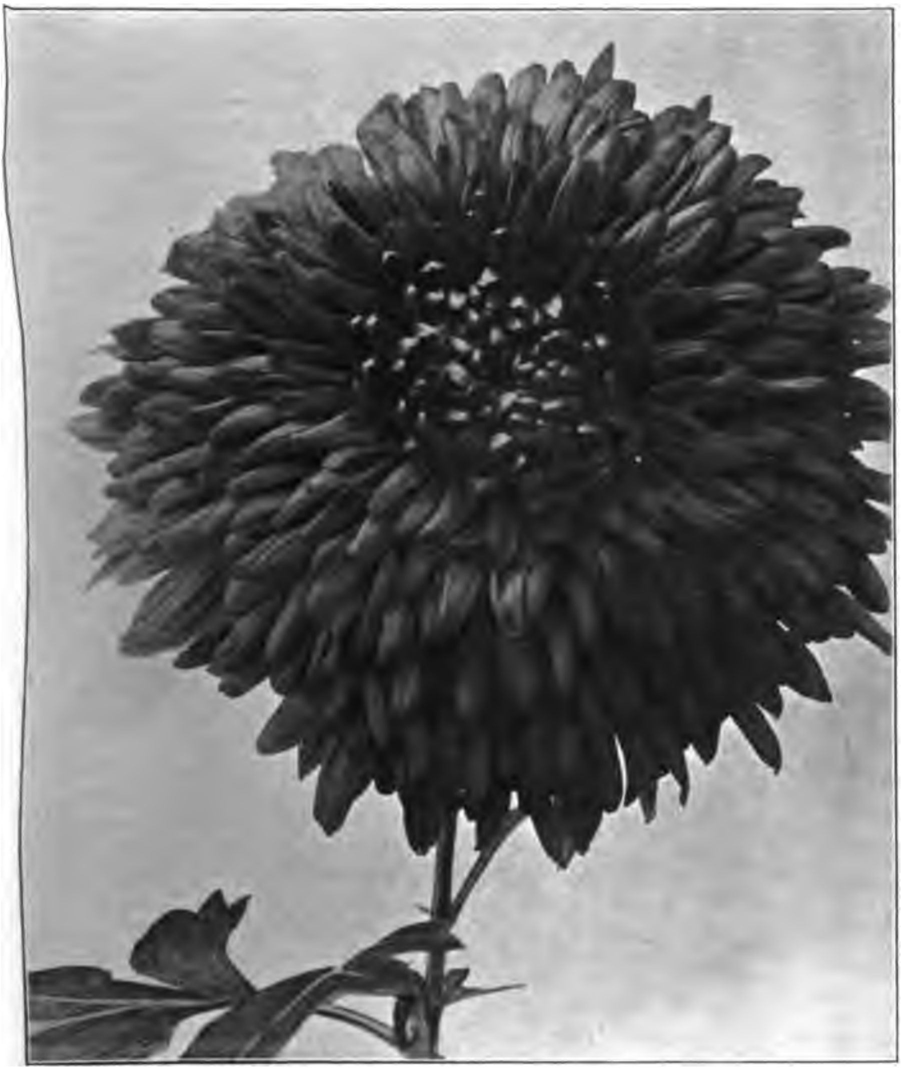
an expanding flower in one of these artistic sections the florist may enjoy, but he cannot sell it.

The whole class formerly called "Japanese Reflexed" but now included in the Japanese section by the National Chrysanthemum Society of England, is of especial interest to the amateur. Day by day new characters appear. Successive tiers of florets flop over and the entertainment is ever changing. *Shavings* is full of curious motions before it looks like figure 185, page 689. *Geo. S. Kalb* has two different expressions and the change comes quickly.



177. *An early stage of Millbrook. See Fig. 178.*

This watching of daily changes is one of the chief rewards of cultivating plants. A cut-flower is bought at its perfection and changes little. A potted plant like that in Fig. 179, has a higher beauty than any cut flower. It has the greater artistic value of different sizes and shapes, even if one does not watch the flowers develop. Such a plant may be bought from a florist, but there is nothing like growing it yourself. The plant in Fig. 179 is *J. W. McHattie*, but the name does not matter. Almost any dark



178. *A later stage of Millbrook. See Fig. 177. These changes are good things to watch.*

colored variety gives a fine mass effect, especially when there is a suggestion of gold in the backs of the young florets, to set off the rich reds of the developing flower. The plant in Fig. 179 is more symmetrical than that in Fig. 175, and there are no stakes or strings to be seen. It is only one of many beautiful shapes that may be obtained.

179. *What anyone may raise with care in the home window.* (*Variety, J. W. McHattie.*)

III. CONTROLLING THE COLOR OF CHRYSANTHEMUMS.

Out of thirty-one pink flowered varieties of different shades and grown under the same conditions at the Cornell Experiment Station in 1897, fourteen turned out to be practically pure white, while three others showed much less color than the descriptions call for.* This was no accident. The varieties were true to name. The flowers averaged six inches in diameter, and were satisfactory in every other respect. The color alone was lacking.

The economic importance of this fact is very considerable. At least a fourth of all the new varieties are advertised to be pink. Perhaps also, a fourth of all the cut flowers sold are pink or something near it. The market reports, at any rate, often quote only four groups, white, yellow and pink chrysanthemums, and "other colors."

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*These varieties were G. F. Atkinson, Mrs. Theo. F. Beckert, Belle of Castlewood, Bellem, Brian Boru, G. Carvell, Col. Curzon, Miss A. L. Dalskov (Syn. Pink Ivory), Mrs. W. C. Egan, Elainora, Gladys, Sibyl Kaye, Gov. Matthews, Merula, Rose Owen, Mrs. A. H. Wood, J. H. Woodford.

The case would not be so serious if all the pink sorts were able to lose their color gradually and uniformly, and still remain attractive, as *Iora* does. Unfortunately they do not. As a rule they fade out unevenly and look weak, blotched, undecided. The mass effect may be good, but one cannot look at the flowers closely. Two specific examples may be cited as typical of two different phases of the problem.

One of the important commercial varieties of to-day is *Fred Walz*, yet it frequently shows three or more easily distinguishable shades of pink in the same greenhouse. Being somewhat stiff and formal in outline, it is easily ruined for artistic effect by unevenness of color. Now, the amateur usually grows many kinds and few specimens of a kind, but the florist pins his faith to a very few varieties. It is a common practice for him to depend upon only one or two varieties to furnish all his cut-flowers of a given color. Moreover, the very compactness and formality that make *Fred Walz* a distinctively commercial variety (for these traits are associated with cut-flowers that stand a railway journey nicely) are the same qualities that betray the fatal unevenness of color. An eccentric form may have eccentric coloring. The ragged, straggling sorts are usually valued for their freedom of form rather than for their color, but a perfectly regular, globular flower must be of one tone to have a unity of color effect. The whole Chinese section is very formal, and there are dozens of varieties in the Japanese section that are in the same predicament with *Fred Walz*.

As *Fred Walz* is typical of a form of flower that is suitable for shipping, so is the white variety *Ivory*, a type of certain habits of plant growth much sought after by the florists. Most American dealers place it on a list of twelve best varieties for commercial purposes. The amateur likes it, and it is used for exhibitions, for pot-plants and for cut-flowers. It is, in short, a typical "all-round" variety. Naturally pink sports of it are in great demand, but they are hard to retain. One of these many efforts is *Miss Agnes L. Dalskov* (commonly called *Pink Ivory*). It has been much praised elsewhere but with us it had no color at all in 1896, and even from our own stock, showed barely a trace of it in 1897.

But this is not all. The trouble is not confined to the pure pink color. As a matter of fact, the pure pink of F. Schuyler Mathews's color-chart has not yet been attained in chrysanthemums, but this is not so serious in itself, for it means only one particular shade. There seems to be an entire series of colors whose value is determined far more by the skill of the cultivator than by the variety. Here are some of the grades in this "pink" series; amaranth, crimson, rosy pink, crimson-pink, light pink, and blush-white. These are current trade names, not artists' terms. It seems probable that any of these shades may, in some cases, be obtained from a single variety. Not all varieties, of course, are so highly variable as this, but frequently the difference is enough to make the flowers unsalable.

The control of color, therefore, becomes a problem of great practical interest. It is doubtless a complicated problem. There seem to be at least six factors concerned, any one of which may change a pink to a white. (1) The choice of buds is said to be sufficient in some cases. Thus, *J. H. Woodford*, one of Mr. Spaulding's novelties, is advertised as shell-pink from terminal and pure white from crown buds. (2) Over-propagation is generally believed to weaken colors. (3) Temperature and ventilation (the two factors can hardly be separated in greenhouse practice throughout the entire year) are advertised to produce three distinct and desirable shades in *Mrs. Col. Goodman*.* (4) Mere position (in pots, beds or benches) should not in itself make a difference, but in practice it does. (5) The effect of shade is variously stated. (6) And, most complicated of all, the food factor is known to influence color, but just how is a mystery.

It was convenient to single out only two of the supposed factors this year. We resolved to see whether shading the flower buds would make the flowers a darker or lighter pink, and whether a liberal supply of nitrogen would weaken or deepen the colors.

The conditions of the experiments are briefly given. Sixty plants representing seventeen varieties were used in the two experiments, but ultimately only twenty-six plants, representing seven varieties, were strictly comparable in each experiment, for reasons stated hereafter. Each plant had four long branches, and each branch bore one flower. The flowers averaged about five inches in diameter. The cuttings were rooted early, and the plants shifted successively to six-inch pots in which they were flowered. The same potting soil was used as for all the other potted chrysanthemums, which was 3 parts rotted clay sod, 1 part sand and bog mold, but no manure. The object was to produce typical potted plants of a salable character by the methods commonly used by florists, and all the plants proved to be of this character, though some of them were not typical of the variety as to color, and some could not have sold for pink flowers. In only two respects was the common treatment varied.

In the shading experiment, 24 plants were exposed to the sunlight at every stage of their growth, while 36 plants were shaded soon after the flower buds appeared by means of a rather heavy coat of whitewash applied to the glass directly above them. Some of the varieties in the experiment were shaded from the time the buds were the size of marbles until they came into full flower. Others had already burst their buds and were out an inch or more before the glass overhead was whitewashed. This coat of whitewash remained until the flowering season was over.

In the nitrogen experiment, 23 plants were given only the amount of nitrogen which all our potted plants received, while 37 plants were given an extra supply of nitrogen. This extra supply of nitrogen was applied in liquid form. It was a solution of nitrate of soda. In 100 lbs. of this nitrate of soda, there would be 13.90 lbs. of nitrogen. The applications were begun when the plants were well rooted in the flowering pots. At first the interval between applications was four days. Later it was reduced to three. When the flower-buds appeared the applications were stopped.

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* High temperatures with close air tend to weaken colors. Conversely cool temperatures with plenty of air tend to deepen the colors.

The results of the two experiments were very interesting, and contrary to what I had been led to expect from some statements in the trade publications. Shade is said by some to deepen the color, but the reverse was true in this case. The difference was perceptible at once in five varieties (*Mrs. Perrin*, *Madame Felix Perrin*, *Marie Valleau*, *Helen Bloodgood* and *Iora*) and at second glance in two others, *William Simpson* and *Maud Dean*. In only two cases, however, was this difference enough beyond question to destroy their salable character, but they are the most important varieties in the list. *Mrs. Perrin* and *Madame Felix Perrin* are among the most important midseason commercial sorts of the day. They are so much alike that only an expert can tell them apart. Their peculiar charm is their sparkling, bright rosy-pink color. The flowers of these two varieties, whose buds were shaded, were very uneven in color. The loss of color was the only loss, and it alone was enough to destroy their salable character. This cannot be attributed to a general lack of vigor in the plants. The experiment shows clearly that during the reproductive phase the forming flowers are extremely sensitive to shading and are sometimes practically ruined by it. There was only one contradictory plant among twenty-six that were strictly comparable.

This experiment deals only with obtaining a good degree of the pink color, and does not show how the color once secured may be retained. The fading of the pink varieties after the flowers are once fully expanded is a different matter, and is beyond control at present. It may be the inevitable associate of uncontrollable chemical changes that are not understood. All the pink-flowered varieties in the forcing-house began to fade as soon as the flowers were fully expanded, no matter whether they were in sun or shade. Some faded very slowly and in others the change could be noted day by day. It seemed to be a matter of variety. We could discern no other principle.

There is another interesting fact which should be put on record in connection with chemical changes and change of color. In still earlier and later stages than any referred to above, it is common for secondary colors to appear. I have noted some thirty white varieties that show pink at late stages. Sometimes this secondary color is attractive and prolongs the season of the flower and adds to its charm, but it is commonly associated with loss of crispness and marks the end of the salable period.

The results of the nitrogen experiment were not certain enough to be published, but it is safe to say that the extra amount of nitrogen did not seem to deepen the color in any case. Of the 60 plants used in the two experiments, only 26 were strictly comparable. The others may be arranged in three groups.

In the first group were 8 plants of 3 varieties (*Violescent Rosy Imperatrice* and *Sibyl Kaye*), which did not attain their typical color under any of the four kinds of treatment, but had shown enough color (although short-lived in the last two varieties) in 1896.

In the second group were 13 plants of 5 varieties (*Gov. Matthews*, *Miss A. L. Dalskov*, *Mrs. W. C. Egan*, *Mrs. Harry Toler*, and *Bellem*) which, like the first group, did not attain their typical color under any treatment, but unlike the first group, they had not attained their typical color in 1896. In both groups the second year's trial resulted in no gain. In these particular cases the home grown stock did not, of itself, give enough advantage to make the flowers well-colored, but these results must not be taken as contradicting the established principle that home-grown stock, if carefully selected, gives better results than newly purchased stock that has not been carefully selected.

In the third group were 14 plants of 2 varieties (*Lenawee* and *Our Mutual Friend*) that are not normally pink, but white. In *Lenawee* I had never seen any pink color, but in *Our Mutual Friend* I had noticed, in 1896, some flowers that showed almost enough pink to make them unsalable as white flowers. These plants had been highly fed, and under the same conditions the normally pink varieties had been very highly colored. This treatment, I believe, was very liberal with nitrogen. Nitrate of soda, says one chrysanthemum specialist, deepens the color of certain pink varieties. If one kind of treatment deepens the color of pink flowers, may it not force some pink color into white ones? This query explains why two normally white varieties were included in these experiments with pink varieties. In these experiments *Lenawee* and *Our Mutual Friend* showed no color at all.

It should also be said that *Bellem* and *Marie Valleau* are sometimes described as chiefly or entirely white, and sometimes as chiefly or entirely pink. I have not excluded *Marie Valleau* from the list of varieties that were strictly comparable, as the flowers of it grown in the sunlight would have sold as pink flowers and not as white ones.

Next to the pink series of colors, the bronzes seem to be most sensitive, and next come the dark colors, especially the darker reds. All the bronzes I have seen are blendings of red and yellow, and the two elements are often easily separable. Thus *Charles Davis*, one of the leading commercial sorts, is recorded in the magazines in every shade from rosy bronze to pure yellow. Yellows will show red, and bronzes will lose it but the changes are probably not so serious in dollars and cents as the loss of color in the bright pink varieties.

IV. CROWN AND TERMINAL BUDS.*

The choice of buds in chrysanthemums presents some phenomena that are extremely interesting and absolutely unique in the cultivation of plants. At the outset it should be said that the whole subject may be safely ignored only by amateurs who do not grow flowers for the shows. Every competitor at the shows, and every florist who tries for the earliest flowers on the market should master the subject. While the terminal bud is the best for general purposes in America, the crown bud usually gives the earliest flower, but there are exceptions to both rules. The whole problem is a curious one. One kind of bud will sometimes give an incurved flower and another a reflexed flower, and other great changes in form may occur not often only in the same variety but actually on the same plant. Terminal buds give pink flowers, while crown buds may give flowers that are pure white or nearly so. Form and color may be so completely changed as to make the variety entirely unrecognizable ; foliage is often seriously affected, and in short, the bud factor alone may make all the difference between success and failure in competitive exhibition.

A proper perspective of this subject may be gotten only by reflecting on the importance of disbudding in the amelioration of plants. The Chinese and Japanese seem to have practiced the disbudding of chrysanthemums from an antiquity that is scarcely credible to the western mind. Their achievements are just as wonderful as if we had produced the same forms and colors from our own much hated weed, the ox-eye daisy (*Chrysanthemum Leucanthemum*) by disbudding and by patient care through the centuries. In 1845 chrysanthemums had barely emerged into some degree of general notice in England, and the oldest extant horticultural journal of the country was in its fifth year. Yet in the *Gardeners' Chronicle* of 1845, a chrysanthemum culturist mentions disbudding as an essential. For the last twenty-five years, at least, English gardeners have been using the terms "crown" and "terminal" buds in a technical sense peculiar to chrysanthemum culture alone. These words have grown in a natural fashion, and nobody knows when they were first defined in their present sense. Although the literature of this subject is very extensive, the phenomena have never been illustrated, so far as I know, by more than two sets of pictures. What, then, are these unique phenomena that gardeners have noticed for twenty-five years, and what are crown and terminal buds?

A crown bud is surrounded by vegetative shoots, and not by other buds. See figure 180. *A terminal bud (in chrysanthemums) is surrounded by other buds and not by vegetative shoots.* See figure 181. These definitions may be literally adhered to for practical results. The chrysanthemum specialists are pretty well agreed in accepting these definitions, but there is reason to believe that hundreds of the lesser growers in America have entirely missed the whole problem. This is due chiefly to the fact that chrysanthemums for commercial purposes are planted out much later than

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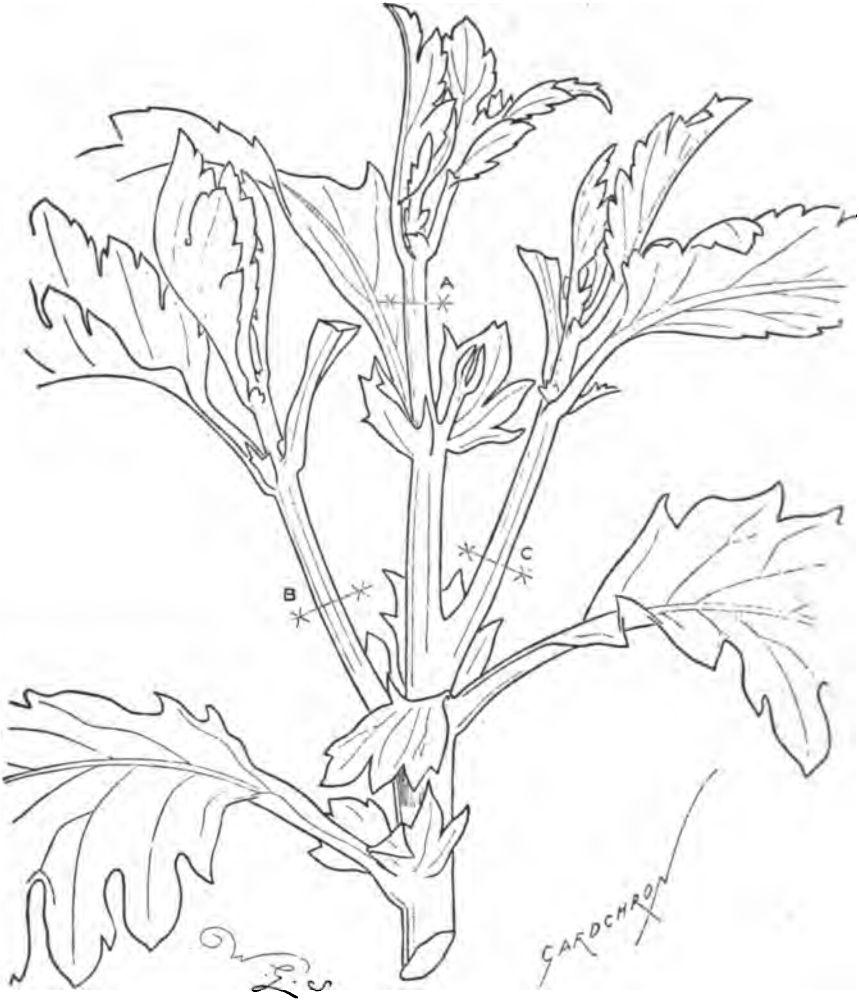
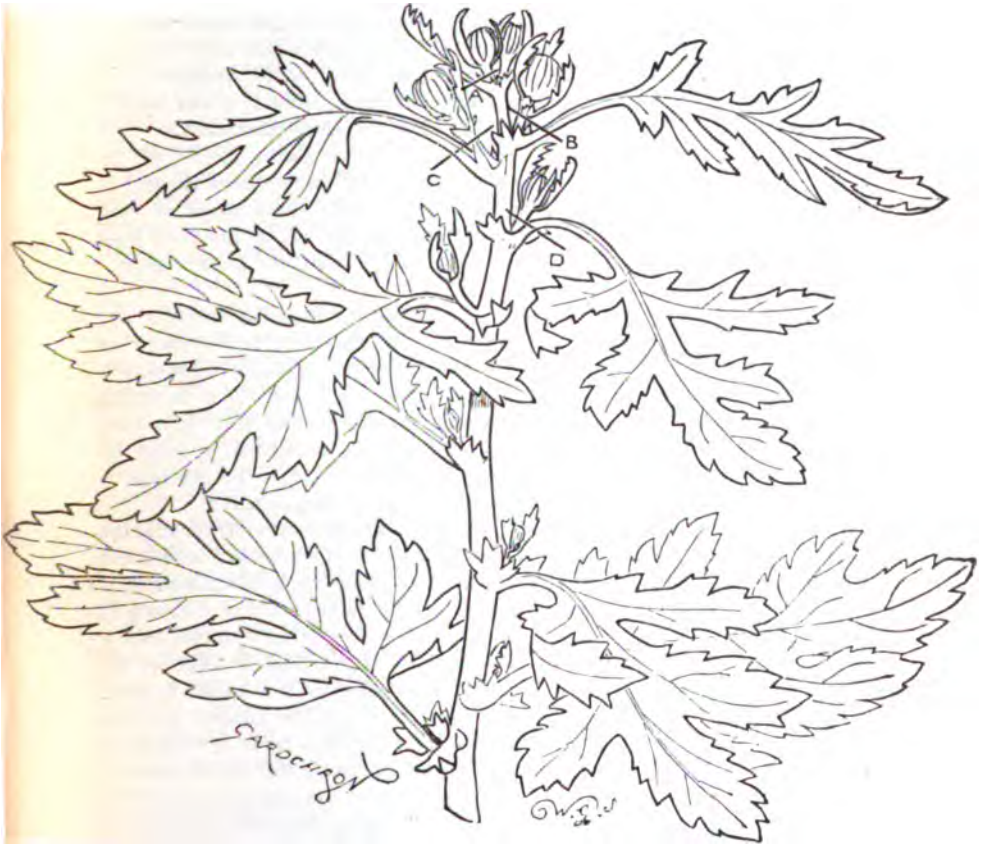
*This account is slightly extended from an article in the *Florists' Exchange* for March 26, 1898.



180. *A crown bud is seen below A. To save the crown, cut off the shoots A, B and C. To secure a terminal bud cut off the crown bud and the shoots B and C. The shoot A will eventually bear clusters of flower-buds as in Fig. 181.*

in England, July 12 to 20 being the American rule. Now, late struck cuttings give very few crown buds, and the state of things pictured in figure 180 very rarely occurs in America except when plants are started very early for special purposes, such as exhibitions and standards. As a consequence, it is commonly supposed that the crown bud is the top bud of the cluster shown in figure 181, and that the only question to decide is whether to keep that one, or one of the other flower-buds of the cluster. Thus the whole point is missed entirely, for it is a matter of time primarily, and only incidentally a matter of position. (As a matter of fact, the central bud of the cluster is much larger and rounder than it is shown in figure 181, and usually gives the best results. But a bug may nip it, or an accident make it useless.) This widespread popular misconception must be entirely removed at the start. The mistake, however, is an easy one to make for other reasons. Every good catalogue now-a-days tells in many cases which bud to use, the periodicals reiterate the directions, the mass of writings on the subject is



181. *A cluster of terminal buds. Whichever one is saved becomes the terminal bud. Note that there are no vegetative shoots. This and Fig. 180 from The Gardeners' Chronicle.*

very great and the beginner naturally infers that the choice is always offered to him, and that it is a mere matter of choosing. Only the experienced grower knows that he cannot always get what he wants, and that he must scheme for his crown buds—plan for them a whole season in advance. A third source of error is the terminology. How shall a beginner know that "taking" a bud is really leaving it? And moreover the word terminal covers two distinct ideas of great practical importance which can be separated only by close observation and thinking. Thus, when the shoot A in figure 180 was very small, the little flower bud seen below it in the picture may have actually reached higher up into the air than the shoot A. The flower bud was then the terminus in the sense that it was at the top of the stem. But it does not stop vegetative growth. It does not mark the end of vegetative stage, and the beginning of the reproductive stage of the plant's life-history. Not at all. But in figure 181 the whole cluster of buds does actually stop the vegetative phase altogether until the flowering time is over.

In figure 180, the vegetative shoot A is shoving the little flower-bud aside, sapping its vitality, and will soon straighten out the axis of growth so that one would never know the difference. The flower bud remains rudimentary or dormant. The whole cluster of buds shown in figure 181 is terminal because it ends the vegetative phase of the plant's history, and it is only the particular bud in the cluster that is left to flower which is what the chrysanthemum specialist calls *the* terminal bud. Finally the beginner is easily led to mistake the whole problem by such writing as this:

"For garden purposes, the term 'crown' bud does very well, for it is the center or crown of a group of buds[1] at the end of the growth; indeed the term can only be fully appreciated by those who have a practical knowledge of 'taking' the buds. There is the larger bud in the form of a crown in the center, and standing above all the others. [The true terminal bud of the botanist.][2] The question to be determined at the time is, whether the center bud shall be left or taken out; in some instances it is better to leave it and remove the side buds with the finger nail; in the case of another variety, the center bud is removed, and one of the side buds is trained up to take its place, and this bud, to all intents becomes the terminal bud, with a number of lateral buds clustering around it; but except that the two terms are in general use, there is no reason why 'terminal' should not apply to each."[3]

How many beginners reading the above and seeing no illustration would infer that the whole problem was merely to choose between the center and one of the side buds in a given cluster of flower-buds? Nearly all, I think.[4]

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[1] Does not the reader here naturally think of a cluster of flower buds as in figure 181?

[2] This seems to be the comment of the editor of *Gardeners' Chronicle*.

[3] J. Douglas in *Gardeners' Chronicle*, Nov., 1893, p. 620.

But why are crown buds wanted at all? One reason is that the crown bud sometimes gives a flower ten days earlier, which is an important consideration to those commercial florists who make a point of getting the earliest blooms of the season into the large cities. Moreover there are many sorts which would naturally bloom too late for the exhibitions. Some of these may be secured for an arbitrary date by the use of crown buds. As a rule the crown bud gives a larger flower, and mere size alone is valued out of all proportion to its artistic worth at the shows. Again, some weak and crooked-growing plants are straighter and stiffer under crowns than terminals. Finally, in some cases crowns give better results (taking all things into consideration) than terminals. Such cases should be regarded by Americans as exceptions to the general tendency, but they are very numerous. Earliness and size, then, are the chief merits of crowns and they are often at the expense of many and serious defects.

The general tendency among crowns is towards a loss in form, substance, color, and foliage. The regularity of the incurved section (which is aided in the English shows by artificial "dressing") is often lost. The whole outline may suffer, the broad, ragged florets hanging in a heavy, flabby mass instead of curving inward to make a solid ball. They are often "hollow-eyed," and there may be several yellow discs or one so badly confused as to be called "cross-eyed." Superfluous florets commonly mar the unity of effect, and it is even recorded that the tubularity of florets may be affected. The flowers often lose in depth and solidity, the stems are devoid of foliage near the flower, the keeping qualities are sometimes spoiled, and the colors lose both in quality and quantity. Probably exceptions could be cited in every point above-mentioned, but some of these symptoms are likely to occur even in blooms that win prizes.[5]

The crown bud is often spoken of as essentially abortive in its nature. The analogy is helpful. In figure 180 the small bud below A may be looked upon as nature's device for making the plant branch. It is not designed to produce flower or seed itself, but by giving a temporary check it makes the plant branch and a branched chrysanthemum stands a better chance in the struggle for existence than an unbranched one, because it bears more flowers and therefore more seeds. The chief merits of crowns, viz., earliness and size, may easily be explained by the earlier setting of the bud and the longer period of growth.

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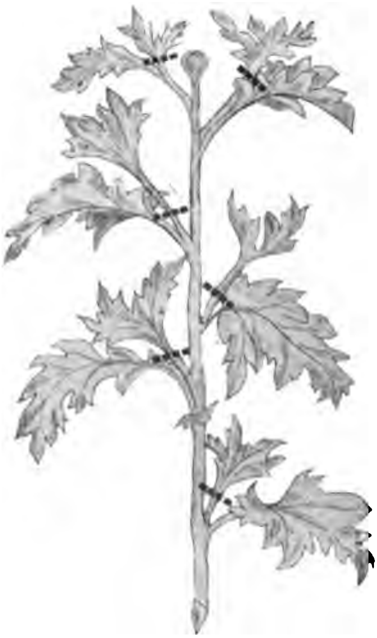
[4] I cannot imagine that the veteran cultivator, Mr. Douglas, has missed the whole point. His subsequent writings make it seem impossible. And it would be very odd if Mr. Molyneux, who is the chief writer on this subject, and who was engaged with Mr. Douglas in a controversy at the time, should have overlooked so complete an error. It is misleading only, and the trouble comes from using "buds" when the writer should discriminate between a flower-bud (the crown) and its accompanying vegetative shoots. These young growths ought not to be called buds, but shoots.

[5] Exception may also be taken to the direction of a general tendency. Thus Grove P. Rawson writes in the American Chrysanthemum Annual, 1895, "Crown buds in general are preferable for exhibition flowers, especially when they are shown on boards, as was formerly the practice. Foliage and stem not being taken into account, the blooms from crown buds average larger, fuller, clearer tone of color, and have more substance than the terminals."

Terminals, on the other hand, are likely to be better in every way except size and earliness.

The practice of bud-taking may be formulated into the following rules, but there are numberless exceptions, and, not to mention other complications, two factors alone—the locality of the grower and the date of the show,—are enough to make the whole matter a personal problem.



182. *Another picture of a crown bud. (This and Fig. 183 were adapted from Mr. Molyneux's book and used by Elmer D. Smith in The American Florist; 9:8, Aug. 1893.)*

(1.) The season may be lengthened at both ends by the judicious choice of buds.

(2.) Crowns may be used on late varieties to show them at exhibitions for which they would be naturally too late. Conversely, terminals may be used on early varieties for a similar purpose.

(3.) Crowns may be used for close-jointed and terminals for long-jointed varieties. This does not mean that on dwarf varieties crowns will give better results than terminals. It means that tall, long-jointed varieties are likely to become too tall and bare-necked under crowns. Dwarfs under crowns may be elongated just as much relatively as tall sorts under crowns, but not so much absolutely.

(4.) In England crowns are preferable in the north, and terminals in the south, in order to compete at the London shows.[6]

(5.) In England, crowns are preferable for the Japanese sorts, and terminals for the incurved.[7]

(6.) Never keep a July bud.

(7.) In England, the best time to select crowns is between August 18 and September 1[8]. In America most of the crown buds are selected between

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[6] W. Hinds in *Gardeners' Chronicle*, March, 1879, p. 376, where the writer states that the North Country growers would have few flowers before December except for general decortion unless crowns were used. Similar statements have been frequently repeated.

[7] E. Molyneux in *The Garden*, 34 : 228 (1888).

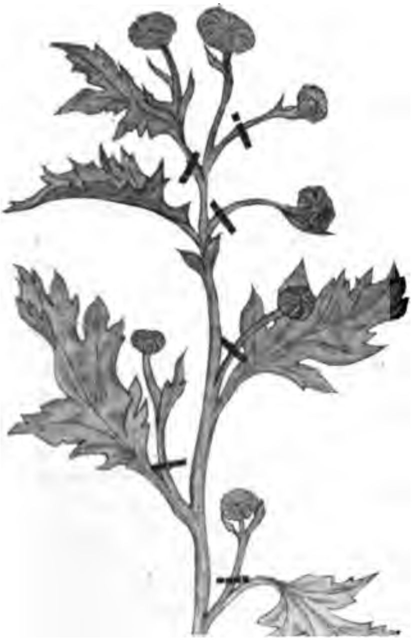
[8] E. Molyneux in *The Garden*, 34 : 228 (1888). H. S. in *The Garden*, 42 : 174 (1892).

September 10 and 15[9]. The difference in time may be due chiefly to climate.

(8.) The later the bud, the higher the color.[10]

(9.) As a rule, crown buds give earlier and larger flowers, which are likely to be deficient in some or all other respects. Chief among these defects, for America, is the long neck bare of foliage.

(10.) The earlier the crown the greater the chances of failure.



183. *Terminal buds. (They are less clustered here than in Fig. 181, and the central bud is larger.*

The differences in practice between England and America are well worth setting forth. Crown buds are used more commonly in England, largely because of the aversion to pinching out the leading shoot at any height. This prejudice is probably not so strong in America. The commercial element is more prominent here, and chrysanthemums for sale as potted plants are started late, kept as dwarf as possible, and grown on side benches where there is the least headroom. Such plants are pinched as early as possible to make them branch. In England, the amateur and exhibiting classes are stronger than in America, and the plants are started much earlier and never pinched to induce branching, but are grown under the "three break" or natural system. The first break may come at any time from April to June 15, and at a height of from one to three feet. The second break is caused by the crown or single buds. If these buds are not selected to produce flowers, but are removed, the third break produces clusters of flower-buds which are called terminals. But, after all, differences in cultural methods do not go to the root of the matter, for they are largely dependent upon differences in public taste. In England flowers are chiefly shown on boards. The stems are cut short and each flower is supported by a collar placed over the top of the vessel of water that holds it, and the leaves are not seen. They are judged as individual objects. Americans like mass-effects, and the feeling for foliage is general. With us a flower without foliage is like a gem without its setting. Our best vase effects are loose, airy, graceful, fluffy, and they are obtained by using long stems and plenty of foliage.

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[9] E. D. Smith in *Florists' Exchange*, 5 : 790, Aug. 1890.

[10] C. E. Shea in *The Garden* 38 : 407, Nov. 1890.

It will now be clear that there are special as well as general reasons why English varieties do not succeed in America as a rule, and *vice versa*. The English favor crowns, and crowns as a rule have poor foliage. Choosing varieties from the exhibition halls is a fertile source of disappointment. There are many general reasons for it, one of which is that the habit is not seen, and a special reason in chrysanthemums is that the show flower may be the product of a crown bud. The practical application to American novelties is also not far to seek. The terminal bud is the rule for American commercial purposes, and no variety that is poor from the terminal may ever hope for anything like permanent general prosperity in America.

The actual work of disbudding can hardly be entrusted to anyone who has not a stake in the welfare of the plants. It needs patient, skillful, interested hands and the highest powers of discretion employed in the growing of plants. If the crown bud is to be selected, all the vegetative shoots should be removed at a stage much earlier than shown in figure 180. Figure 182 shows a better time. If, however, the crown bud is not desired, it is removed together with all the vegetative shoots save one. The shoot A in figure 180 will naturally be given the preference as it may be expected to give a straighter stem. The shoot that is saved will eventually bear a cluster of flower-buds, one of which is saved, and thereby becomes the terminal. If possible, the unnecessary buds in the cluster should be picked off earlier than those shown in figure 181. The earlier the better, if successful, but the risk in handling is greater. The more the flower buds are advanced, the easier is the manipulation, and the less is the amount of plant energy saved which should be concentrated into the development of only one flower. The same rule applies in the choice of the crown, but the principle is different. In selecting a crown, the cultivator removes shoots; in selecting a terminal he removes flower-buds, and therefore he saves in the first case energy of vegetative growth, and in the latter case reproductive (i. e., flowering) power. Some cultivators use a tooth-pick to dislodge the very young parts, and others wait until they can be picked or cut out with a knife. Others are expert with the thumb-nail. Mr. Molyneux advises that the work be done in the early morning, or in the evening when the parts are brittle and may be snapped off. The ingenious cultivator is likely to invent all sorts of methods and formulas, but the work is tedious at best.

In the description of novelties the trade catalogues, as a rule, give directions about the buds. This is especially true of the English catalogues. As a rule, also, whenever no directions are given the American cultivator has a right to infer that the terminal bud is to be preferred. Every silence, when the opposite is true, is an invasion of the rights of the purchaser by the disseminator. As a rule, however, exhibitors cannot afford to put any large share of faith in novelties. The special cultural requirements of varieties are indefinitely varied and complicated, and a cultivator can hope for nothing more than acquaintance with a new sort in a single season. Often and often he fails and cannot be sure of the cause of his failure. Mercilessly cut down the list of varieties and learn the chosen few like a book! The references to the behavior of *Viviand-Morel*, which is only one variety, would probably occupy three times the space of this entire article, if gathered from the various magazines.

After the flower has opened it is not always possible to tell from the plant itself which kind of bud was used. Sometimes it is possible. This year we ascertained from catalogues and by correspondence the bud preferred by the grower for each named variety, and we have records of the exact date when each of more than 600 buds was taken. The characters used to identify the results after flowering are age, size, color and form of flower-head, size and form of the yellow disc, number, size and form of florets, length of bare neck, size, position and form of scars, and the angle of divergence caused by the removal of parts. In my limited experience no one of these characters, nor any combination of them, made it certain in even a majority of cases what bud had been used.

The terms "early" and "late crowns" are much used in England, and the terms "first" and "second buds" are less commonly seen in American catalogues. The two sets of terms are synonymous and refer to the fact that a crown bud may be removed, and the shoot selected to continue the growth may bear a single bud which is called a "late crown," "second crown," or "second bud."

If, now, this "second crown" is removed, a cluster of buds may subsequently be secured and the one reserved for flowering is of course the terminal.[11] The reason and relation of these phenomena may be cleared up by reflecting that all crowns, i.e., all flower-buds that appear singly (and they may appear in almost any month before the clusters of flower-buds come) are essentially premature and not designed by nature to produce flowers. "Early" and "late" are therefore seen to be only relative terms, where months of the year might be specified, and "first" and "second" refer only to the effects produced by the removal of parts by the cultivator.

It is, of course, useless to try to divert the growth of language. A more logical terminology would use "first natural break" for the branching that takes place when plants are started very early and grown continuously without a check. "Single" and "cluster buds" mean something. "Crown" and "terminal" do not mean anything on their face, and their technical use in chrysanthemum culture violates botanical usage and must be arbitrarily memorized. "First single bud" and "second single bud" are awkward at first, but they are clear. And "taking" the bud is unnecessarily misleading, while we have "use," "keep" aud "save," in the language. It should be stated, however, that nature does not keep to definitions. It is often difficult to say what is a cluster. This doubt is chiefly due to the fact that such a cluster as is shown in figures 181 and 183, rapidly elongates and what one seems to see is a number of buds scattered distantly along the stem. Similarly there may be more vegetative shoots on the same stem with a single flower-bud than the three that are pictured in figure 180. (Six of them are seen in figure 182.) Every axil in fact below that flower-bud wants to make a growth, but as a rule the three at the top get the start. If the student will burn figure 180 into his mind, and understand the definitions previously given in italics, he will have no trouble in knowing a crown from a terminal.

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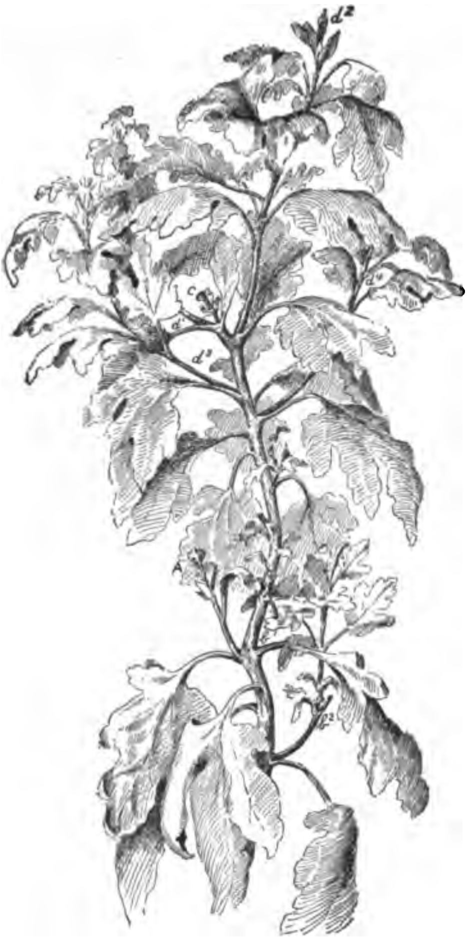
[11] No cluster of buds can ever be referred to as crowns without abandoning all definitions and all clear thinking. I know of no recorded case where clusters of buds appear in large numbers so prematurely as to necessitate removal.



184. *What happened to two crown buds that were not removed.*

Some cultivators will wish to know what happens if a crown bud escapes their notice and is not removed. Fig. 184 shows part a of belated chrysanthemum plant that we allowed to have its own way. The first crown bud was formed at A. Beneath it were two vegetative shoots b^1 and b^2. The upper of the two shoots, b^1, got the start and grew so vigorously that the poor crown bud is side-tracked, and sapped of all its ability to produce a good sized flower. At C, may be seen the second crown bud. This bud checked the lusty growth of the shoot b^1 just long enough to cause the plant to branch. Four vegetative shoots started out at d^1, d^2, d^3, and d^4, and they have sapped the strength out of the second crown bud C. In this case d^2 is the strongest shoot. It has side-tracked the crown-bud C which was once directly in the line of promotion and has now so nearly straightened out the axis of growth that, merely to look at the picture, one might suppose that d^2 is a part of the original stem itself. These four shoots d^1, d^2, d^3 and d^4 would have gone on to produce terminal buds (*i. e.* cluster of buds) but the flowers would be entirely worthless commercially because out of season, and small, and poor in every way.

In conclusion, although the whole matter is one of the last refinements of specialization, its importance for the exhibitor can hardly be overstated. It is often called a vital and critical element, and in a proper sense it may be called the secret of chrysanthemum culture. Aside from the terminology of the subject the present confusion is due to three causes—first, to differences in observation as to what actually takes place ; secondly, to differences in the interpretation of the facts and the generalization of them into rules of conduct ; and thirdly, to differences in the application of these rules. As previously pointed out the problem is in practice essentially local and personal, and after the principles are thoroughly mastered, there is positively no other way for the exhibitor than to make his own dates and buds for his own varieties by yearly observation and experiment.

REFERENCES TO LITERATURE.

The writings on this special subject are exceedingly numerous and scattered, and in the earlier times particularly, references may be found only by the diligent search for them in general cutlural directions and miscellaneous notes. A complete bibliography is out of the question, the labor involved being out of all proportion to the value of the results. Workers in cultivated plants know that completeness is practically impossible in such tasks. I can only hope that the selection I have given covers the essentials of the subject, and represents the most important articles published in the periodicals cited.

ENGLISH PERIODICALS.

The Gardeners' Chronicle.—

Taylor, March, 1851, p. 183. No reference is made to the relative value of early and late buds.

Wm. Holmes, January, 1859, p. 23. This is the earliest mention known to me at present of the different values of early and late buds, and the first use of "terminal" in this special sense. The word "lateral," I take it, is here used as we use "crown" to-day.

R. Fleming, September, 1869, p. 942. This is the first mention of the word "crown" in chrysanthemum culture that I know of, but the term is not yet specialized into the definition quoted previously in italics at page 673 of this bullettn. "Some of the shoots will be found to be more forward than others, and are apt to bloom before them, but by judicious disbudding this may be avoided. This is effected by nipping out the crown or earliest bud of the earliest shoots, leaving a good side bud [He means, I think, a vegetative shoot such as A in figure 180.—W. M.], and retaining the crown or earliest bud of the late shoots; this will cause all the buds to be equally forward."

W. Hinds, March, 1879, p. 376. The writer says that "crown terminals" are favored in the north, and "terminals" in the south.

Editorial, November, 1893, p. 592. This explains that with botanists a terminal bud is at the end of a stem, but that chrysanthemum growers use the term with reference to time, not to position. "For them the terminal is the last bud formed, not the first." The word "final" is suggested to avoid confusion.

J. Douglas, November, 1893, p. 620. An extract from this article has been quoted at page 676 as a type of misleading writing.

E. Molyneux, May, 1895, p. 584.

E. Molyneux, August, 1896, p. 248. This is the earliest picture known to me at present of a crown bud in any English journal.

E. Molyneux, September, 1896, p. 309. The terminal bud illustrated for the first time in any English journal. There is, I believe, an all-important typographical error in the fourth line from the bottom. For "figure 59" read "figure 49."

The Garden.—

E. Molyneux, 34:227, September, 1888.

E. Molyneux, 38:407, November, 1890. Importance of the bud factor in variation of color.

C. E. Shea, 38:407, November, 1890.

C. Gibson, 39:7, January, 1891.

E. Molyneux, 42:173, August, 1892.

H. S., 42:173, August, 1892.

E. Molyneux, 44:126, August, 1893.

AMERICAN PERIODICALS.

The American Florist.—

Elmer D. Smith, 9:8, August, 1893. The cuts enlarged from Mr. Molyneux's book are the only illustrations of this subject that I know of that have ever appeared in any of the American periodicals previous to March 26, 1898.

Garden and Forest.—

T. D. Hatfield, 5:513, October, 1896.

The Florists' Exchange.—

E. Asmus, 3:54, January, 1891.

Elmer D. Smith, 5:790, Aug., 1893.

A. D. Rose, 6:639, July, 1894.

V. THE CORNELL VARIETIES OF 1897.

The variety-test was conducted in 1897 as in the two previous years, but with better results. There were 166 varieties grown as cool as possible in the same house under the same conditions, and with only one plant of each variety. Four flowers were grown on each plant and they averaged nearly six inches in diameter. Inasmuch as a variety-test has no absolute scientific value, but is more nearly related to personal experience, judgments of varieties are here offered, and the descriptive matter reduced to a minimum. Of the 166 sorts grown for comparison, only 86 are now reported upon, as 59 were mentioned in Bulletin 136, and the remaining 21 were chiefly numbered seedlings that were kindly sent by various dealers in advance of their distribution under names. Of the 86 kinds now reported only 54 are novelties of American origin offered for the first time to the trade in the catalogues of 1897.*

It is unfair to finally judge any novelty of any plant on one season's acquaintance, but opinion is called for nevertheless, and must be given. The 86 kinds now considered are divided into only two groups, 34 in one and 52 in the other. In the first group the 10 "very good" sorts are distinguished from the other good varieties by SMALL CAPITALS. The asterisk (*)is prefixed to varieties of foreign origin, most of them being English and Australian sorts of 1896, kindly sent by H. Cannell & Sons, Swanley, Kent, and Robert Owen, Castle Hill, Maidenhead. The dagger (†) means that the varieties are of American origin, and named, but not yet published in trade catalogues. These estimates are our own judgment for our own conditions and may not hold for other conditions and other ideals. The plants were skillfully grown by Mr. Hunn, and his judgments enter largely into the estimates.

The chrysanthemum specialists who have sent their novelties to the station are:

E. G. Hill & Co., Richmond, Ind.
John N. May, Summit, N. J.
Nathan Smith & Son, Adrian, Mich.
T. H. Spaulding, 40 E. 25th St., New York.

Many choice seedlings were sent by the late firm of Pitcher & Manda. Others who publish no catalogues but sent their novelties to the station are J. Condon, 734 Fifth Ave., Brooklyn, N. Y.; Fisher & Ekas, 1st Toll Gate, Belair Ave., Baltimore, Md.; Theo. Bock, Hamilton, O.; and the late Calvin S. Goddard, Woodfords, Me.

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* Fifteen others of American origin were not tried, as follows: Allegro, Miss Lottie D. Berry, Robert Edgerton, Gold Bug, Clara Goodman, Mrs. Col. Goodman. Kentucky, Mrs. A. P. Meredith, Henry Nanz, Pendennis, The Times, Vineta, West Newton, Miss May Williamson, Yellow Monarch. The Californian varieties are excluded from this list, because of their importations from the Orient, and the different cultural conditions.

FIRST GROUP—GOOD AND VERY GOOD.

White-flowered Varieties.

*Early.

MIDGE.—Height 12 to 15 inches. Foliage ideal. Flowers fit to cut from Oct. 5 to Nov. 15. Said to be fuller than *Mme. Bergmann*, the chief early commercial white variety up to this time. An ideal pot-plant.

GEO. S. KALB.—Flowers of the snowball type like *Midge*. Fit to cut Oct. 10 to 28, Fuller than *Midge*. Foliage ideal. Height 22 inches.

Halcyon.—Japanese Anemone section.

** Mid-season.

Marsia Jones.—Japanese Anemone section.

†DR. C. H. PARKHURST.—This was easily the most attractive of all the chrysanthemums grown at the Cornell Experiment Station in 1897. Height 51 inches. Our only plant had four flowers averaging 8x4 inches, which changed in appearance daily for over a month. Unfortunately the neck was weak and bare, due possibly to its position near a steam-pipe. A rich warm white flower. Pictured in *The American Agriculturist*, 61:93, Jan. 22, 1898.

† WM. J. BRYAN.—Flowers nearly as large as the last, later, and a colder white. Habit better, but rather tall. Height 46 inches.

* *Mrs. Jas. Carter.*—Small, a curiosity.

† *Edith Gunnison.*—Flowers large, reflexed, and as good as *Our Mutual Friend.* Not as good as the next for pot-plants.

† *Mrs. J. Condon.*—Flowers small, reflexed and like the last, as good a pot-plant as *Robert F. Hibson*, or *Snow Field.* Not as good as *Edith Gunnison* for cut flowers.

*** Late.

Mrs. Martin A. Ryerson.—A worthy sort to precede *Yanoma*, which is probably the best late white variety.

† *Mrs. Wm. B. Brown.*—In season Nov. 5 to 24.

Yellow-flowered Varieties.

* Early.

GOLDEN TROPHY.—A soft, light yellow flower in salable condition from Oct. 10 to Nov. 15, incurved during the first half of the season and partly reflexed during the remainder. Habit ideal.

** Mid-season.

† *Ophir.*—Flowers rich yellow, globular, rather formal and lasted a month.

Maud Adams.—An interesting type for the amateur.

* *Mrs. Filkins.*—Essentially a curiosity, but beautiful.

*** Late.

† *Levi P. Morton.*—Too late for the shows.

* *A. H. Wood.*—A type for the amateur. See Fig. 176.

Pink-flowered Varieties.

* Early.

ELVENA.—The best early, light pink of its form ever grown at Cornell. Oct. 12 to 24.

** Mid-season.

† *Brooklyn.*—Slow in opening and coarse in color at first. Marketable for a month after Oct. 20. A first rate commercial sort much preferable to *Sibyl Kaye*, which it resembles.

Merula.—Same shape as *Ophir.* Color coarsely lined at first, but afterwards charming.

Chebeague.—A splendid sort for local exhibition. Probably too flat for commercial use. Our's suffered from burned florets.

† *Henry Ward Beecher.*—A rather Chinese type. Color dull, but rich.

*** Late.

Thanksgiving.—The best late light pink we know.

Amaranth-flowered Varieties.

* Showing the silver backs of the florets.

* *Australie.*—The reverse is the chief feature. Only a suggestion of the amaranth interior, and no disc seen.

* *Pride of Madford.*—Both colors show. Disc appears early.

* *General Roberts.*—Flower practically same as the last.

** Not showing the backs of the florets.

* WOOD'S PET.—Early, worthy to precede *Viviand-Morel.*

LEONIDAS.—Early. A different form from the last. Otherwise an equal choice.

Other Colors.

LOANTIKA.—Early. Red, reverse yellow. Worthy to precede *Pluto.*

Chito.—Red with yellow stripes. Flower very large, odd and striking.

CASCO.—An excellent dark sort, early and lasting.

* *Alice Carter.*—Unique, curious, beautiful. A type for the amateur.

* *E. G. Hazeldene.*—Large Anemone section.

Mizpah.—(See title-page.) A single variety, an excellent type and a good pot-plant. One of our plants 14 in. high had 80 flowers at once. Unfortunately they fade and must be picked off.

The varieties above commended are now redistributed into two other groups. The Amateur List contains many of the finer types that the private gardener and skilled amateurs it is hoped will save from oblivion. In both groups the * is prefixed to varieties suitable for pot culture, and the † to those suitable for exhibition.

Amateur List.

White.—† Dr. C. H. Parkhurst, † Wm. J. Bryan, Marsia Jones, Mrs. Jas. Carter, Halycon, * Mrs. J. Condon. *Yellow.*—A. H. Wood, Mrs. Filkins, Maud Adams, Levi P. Morton. *Pink.*—† Elvena, Chebeague, Henry Ward Beecher. *Other Colors.*—Gen. Roberts, Australie, † Chito, E. G. Hazeldene.

Commercial List.

White.—* Midge, * Geo. S. Kalb, Mrs. Martin A. Ryerson, Edith Gunnison, Mrs. Wm. B. Brown. *Yellow.*—* Golden Trophy, Ophir. *Pink.*—Brooklyn, †Merula. *Other Colors.*—Leonidas, * Casco, * Mizpah, Loantika, † Wood's Pet.

SECOND GROUP—LESS PROMISING.

Doubtless there are good sorts in this list. Some of them need special cultural conditions, but in a variety-test they must all be treated alike. If this were a second year's trial of them, we should not have any of these names on our own personal list of 50 for commercial purposes. If any are especially interested in some of these varieties we shall be glad to recount our experience with them.

The phrase "less promising," therefore, expresses merely our own feelings about these varieties, and does not assume to say how these varieties may please others. The plants themselves were well grown when we received them from the dealers and they received careful attention during the entire season.

Adelaide.
Atkinson, G. F.
Barrington, The.
Beckert, Mrs. Theo. F.
Belle of Castlewood.
†Bennett, James Gordon.
Brian Boru.
*Carvell, G.
Castleton.
*Centaurea.
Cole, King.
*Curzon, Col.
Defender.
Devens, Dorothy.
Doone, Lorna.
Douglas, Mrs. R. D.
Elainora.
Eureka.
Evangeline.
Gifford, J. M.
Gladys.
Glessner, Mrs. John J.
Gold Standard.
Golden Wonder.
Harriott, The.
*Hepper, Mrs. F.
Hyde, Mrs. E. F.
*King of Plumes.
Lawn Tennis.
*Levick, Sydney B.
Lorelei.
Mars [Spaulding's].
McKinley, Pres.
McArthur, Mrs. R.
Morse, T. B.
†Nix, Jessie.

*Oceana.
*Owen, Rose.
*Pride of Swanley.
Rothenbush, Mrs. P. [1896, Yoshiike, California].
Spaulding, Dorothy.
Sundew.
Sunstone.
Symphonia.
*Turk, T. L.
Wallace, M. M.
Ward, C. W.
Western King.
Sunclad [1896].
Withers, Mrs. J.
*Wood, Mrs. A. H.
Yellow Kid, The.
Woodford, J. H.

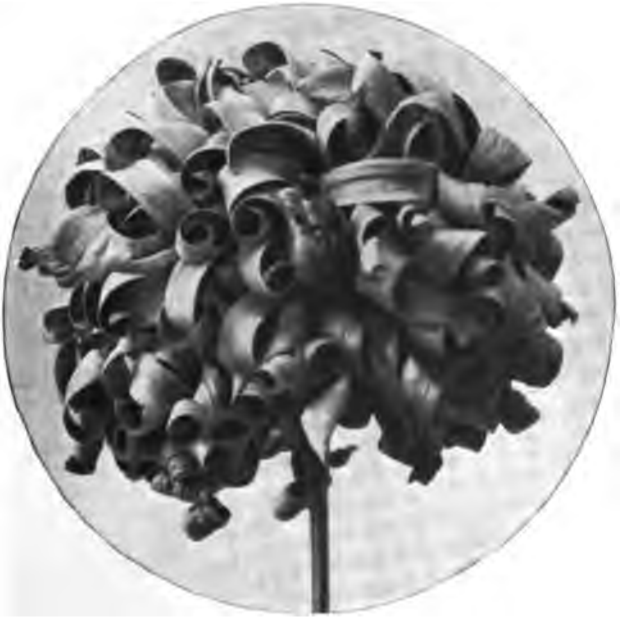
SUMMARY.

1. Special directions for cultivating plants at home are given at pages 660 to 663.

2. Lists of newer varities for special purposes are given at page 688.

3. In order to grow chrysanthemums at home it is not necessary to know the difference between crown and terminal bnds. It is desirable that every florist should master the subject. Page 673.

4. The pink color in chrysanthemums is very unstable. Its regulation depends more upon the skill of the cultivator than on the variety. Pages 668, 669.



185.—*Shavings, an oddity.* (*See page 666.*)

THE FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION TO THOSE WHO MAY DESIRE THEM.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf-Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N.Y., 116 pp.
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78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western N. Y., 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
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129 How to Conduct Field Experiments with Fertilizers, 11 pp.
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131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
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136 Chrysanthemums, 24 pp.
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139 Third Report upon Japanese Plums, 15 pp.
140 Second Report on Potato Culture, 24 pp.
141 Powdered Soap as a cause of Death Among Swill-Fed Pigs, 12 pp.
142 The Codling-Moth, 69 pp.
143 Sugar Beet Investigations, 86 pp.
144 Suggestions on Spraying and on the San José Scale, 18 pp.
145 Some Important Pear Diseases, 36 pp.
146 Fourth Report of Progress on Extension Work, 26 pp.
147 Fourth Report upon Chrysanthemums. 36 pp.

Bulletin 148. **May, 1898.**
Cornell University Agricultural Experiment Station,
ITHACA, N. Y.
ENTOMOLOGICAL DIVISION.

The Quince Curculio.

By M. V. SLINGERLAND.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

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In pursuance of the provisions of Chapter 67 of the Laws of 1898, several persons have been appointed investigators and instructors to serve throughout the state for a portion or all of the year as the demands of the work require.

See Bulletin 146, Report of Progress of work done under Chapter 128 of the Laws of 1897.

Office of the Director, 20 Morrill Hall.

The regular bulletins of the Station are sent free to all who request them

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

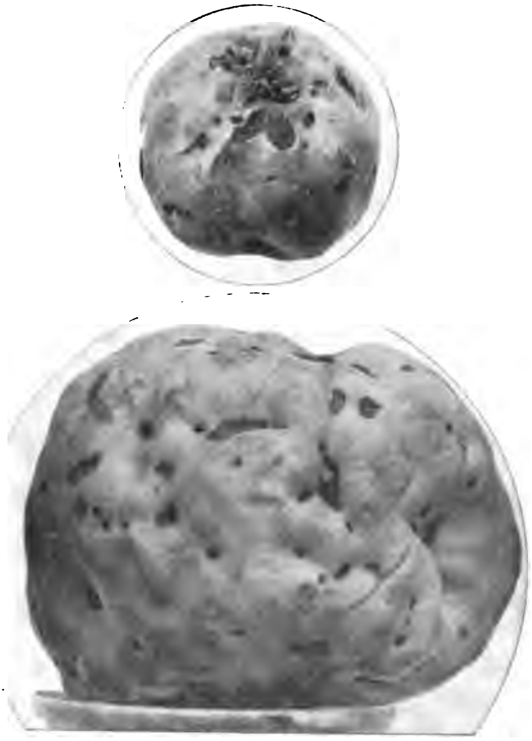
138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.
148. The Quince Curculio.

CORNELL UNIVERSITY, ITHACA, N. Y., May 20, 1898.
THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY:

Sir: This bulletin is submitted for publication under Chap. 67 of the Laws of 1898. It has been prepared by Mr. M. V. Slingerland and embodies the results of experiments extending over two years and the latest reliable facts related to the subject had under investigation.

In 1896, an insect known as the quince curculio was so destructive in some localities as to lead growers of the quince to seriously consider the advisability of cutting down their orchards. Early in 1897, a critical study was begun of the habits of the curculio, and continued during the season until its life-story and habits had been ascertained. Observations show that there is little, if any, probability of poisoning the insect with an arsenical spray, and that early cultivation has but little effect upon it, thus disproving two of the so-called "remedies" by which it has been supposed that the pest could be reached. Our study of its life reveals some striking variations from its habits of the preceding year. By carefully watching the insect in the cages at the insectary, we were enabled to give several large quince growers warning that the pest was appearing in alarming numbers nearly two months later than its schedule time of the preceding year. By following our suggestions, one extensive grower of the quince, whose crop was nearly an entire failure in 1896, due principally to the work of curculio, secured in 1897 the finest crop of quinces he ever harvested. A few careful observations in the cages at the insectary upon the habits of the curculio resulted in the saving of hundreds of dollars worth of fruit in a single orchard.

I. P. ROBERTS,
Director.

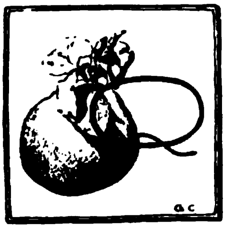


186.—"*Knotty*" *quinces; lower one, natural size, and upper one half natural size.*

THE QUINCE CURCULIO.

Conotrachelus, crataegi Walsh.

Order COLEOPTERA. Family CURCULIONIDÆ.



QUINCES are more largely grown in western New York than elsewhere in the Union. The industry has grown up slowly and quietly, and has not attracted general attention, yet, in its way, it is one of the important agricultural interests of the State. Quince growing can never assume the proportions of other orchard industries, because of the limited demand for the fruit, and for this reason, also, the most careful attention must be given to marketing the crop *and to reducing the injuries from a number of insects and fungous enemies.*”*

The insect enemies which have thus far seriously interfered with the growing of quinces in New York may be counted on the fingers of one hand. Such an enumeration would include the round-headed apple-tree borer, the codling-moth,† the New York plum lecanium scale,† and the insect discussed in this bulletin—the quince curculio. Of these insect enemies, the first and the last one mentioned have caused New York quince growers by far the most trouble and damage ; the lecanium scale was noticeably injurious for only one or two seasons in a few isolated orchards, and comparatively few of the wormy quinces are to be credited to the work of the codling-moth. Quince trees often suffer more from the attacks of the round-headed apple-tree borer than do apple trees. Fortunately, however, this borer is not as yet well established in many of our quince orchards, and is thus rather local in its distribution. One quince grower may have to keep constantly on the alert to prevent the borers from ruining his trees, while his neighbor only a few miles away may never have occasion to dig the "grubs" out of his trees.

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* Bulletin 80, Cornell Experiment Station, The Quince in western New York, by Professor Bailey.

† Discussed in Bulletins 142 and 108.

However, most of the complaint we get from quince growers in regard to insect pests comes in the form of queries about "wormy" and "knotty" fruits. Nearly all of those who grow quinces are only too familiar with such "knotty" fruits as are shown in figure 186. Most "wormy" quinces have been the home of the grubs of the quince curculio, and we believe that most of the "knottiness" of the fruits is caused by the same insect. We have examined dozens of quinces like those figured without finding a single worm, so that often the fruits may be "knotty" and not "wormy." The probable explanation of how the "knots" are produced is given in the discussion of the feeding habits of the curculios.

During the past few years this quince curculio has caused a greater monetary loss to some of the larger quince growers in western New York than all the other insect foes and the fungous diseases of the quince combined. In 1896, 95 per cent of the fruits in one large orchard at Lockport, N. Y., were badly injured, and a very extensive grower at Geneva, N. Y., became so discouraged in trying to check the pest as to seriously contemplate uprooting his whole orchard. However, both of these orchardists are now fighting this insect so successfully that last year they harvested one of the finest crops of fruit the trees ever bore, and this in spite of the fact that in some cases hundreds of the curculios appeared on a single tree during the season; in one instance last year over 200 of the beetles were collected from only seven trees one morning in August. In our discussion of the methods of fighting this pest we have drawn largely from the practical experience of these successful growers.

ITS HISTORY, DISTRIBUTION, AND FOOD.

This insect, which is so serious a menace to successful quince culture in New York, is a native of this country, and its natural food is the fruits of the common wild hawthorn. As early as 1837 one of the beetles had found its way into the celebrated collection of Dejean in Paris, France; but nothing more seems to have been heard of the insect for a quarter of a century. In 1863, it was discovered by Walsh, in Illinois, where it then "swarmed" on the hawthorn. It was reported from Pennsylvania, in 1867, on peach trees, and the next year it was found in New Jersey on pears. It was not until 1870 however, that anything was known of the habits and early stages of the pest. That year Dr. Riley found that it bred very abundantly in the common haws in the west, and Trimble reported that it was breeding freely in quinces and pears in the East; one quince crop in New Jersey was reduced from 100 to 30 barrels, and late varieties of pears had also suffered severely in New Jersey, Pennsylvania and western New York.

This is the first definite record of the occurrence of the insect* in New York, and there seems to have been no other report of its occurrence in the state in injurious numbers for eleven years. Nearly every year since 1881, however, western New York quince growers have reported that a large percentage of their fruits were "wormy" or "knotty." We have also seen evidences of the work of the pest wherever we have found quinces growing in the central and eastern parts of the state.

Cooke records having captured two specimens of the insect in California in 1882. There are specimens in the National Museum from the District of Columbia, Kentucky, and Canada, and in the LeConte collection at Cambrige, Mass., from Georgia; and it is also known to occur in Michigan. Thus, it seems to be quite widely distributed throughout the eastern, central and extreme western portions of the United States and also occurs in Canada. It doubtless breeds freely in the wild haws in these regions, and in the East has unfortunately developed an especial liking for the quince, and often attacks the pear also. It has not been recorded as breeding in apples, and, although the curculios will feed freely on apples in confinement, efforts to induce them to breed in apples have failed. Thus, during years when there are few or no quinces, the insect doubtless breeds in wild haws or pears rather than in neighboring apple orchards.

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*It is quite probable, as Riley stated in his 3d Missouri Rept. that Dr. Fitch had met with the grubs of this insect in haws in New York as early as 1859, but had mistaken them for those of the plum curculio. The context in Dr. Fitch's "Address on the Curculio and Black Knot on Plum Trees" (Trans. N. Y. State Agr. Soc. for 1859, p. 609), indicates this fact. The plum curculio has rarely, if ever, been recorded as breeding in haws, while these fruits are the natural food of the quince curculio.

THE CHARACTERISTICS AND APPEARANCE OF THE INSECT.

Like all beetles, this quince curculio passes through four different stages during its life—the egg, larva or grub, pupa, and the adult or beetle. It is injurious to the quince in two of its stages. The beetles "sting" the fruits, forming many of the familiar "knotty" places, as shown in figure 186; and "wormy" quinces (Fig. 194) are the work of the grubs or larvæ. Quince growers should thus familiarize themselves with these two stages of the insect. The other stages—the egg and pupa—are discussed later on in connection with the story of the life of the pest.

The beetle or curculio.—The pictures of the curculio, natural size and enlarged (side and back views) in figure 187, and still more enlarged in the frontispiece, will give one a very good idea of the general appearance of this stage of the insect. It is somewhat larger than the common plum curculio, has a comparatively longer snout, and is very "broad-shouldered."* For comparison, we have introduced, in figure 188, an enlarged picture of the plum curculio, the pest with which every successful plum, peach or cherry grower is usually already too familiar. Note the peculiar elevations or "humps" on the back of the plum curculio. There are no similar elevations on the quince curculio, whose wing covers are simply longitudinally ribbed with seven narrow ridges, with two rows of punctures in each space between these ridges. Its general color is of a rather uniform brownish gray, mottled more or less with white, especially on the thorax.

The peculiar long snout possessed by this quince curculio, in common with all the other members of the immense family of snout-beetles, is of peculiar construction which well adapts it to the many uses to which the beetle puts it. This snout is simply

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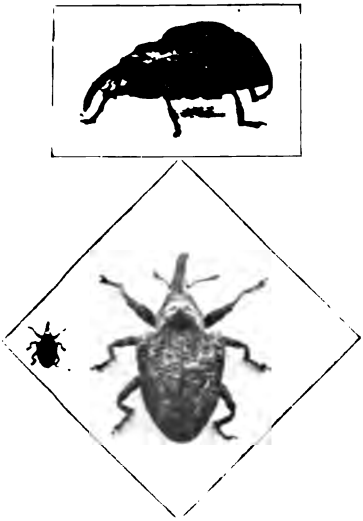
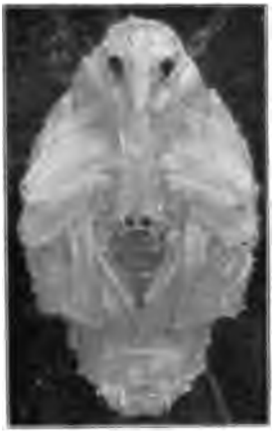
*LeConte and Horn state that this curculio is "broader and more squat than any other of our species, and it is easily distinguished by the humeri being obliquely truncate, with the outer angle dentiform."

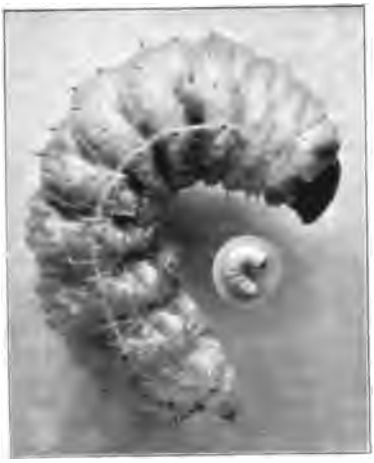


187.—*The quince curculio, natural size and enlarged.*

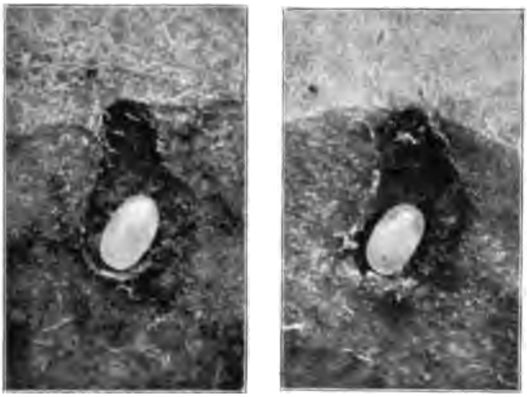


190.—*The pupa of the quince curculio, enlarged.*

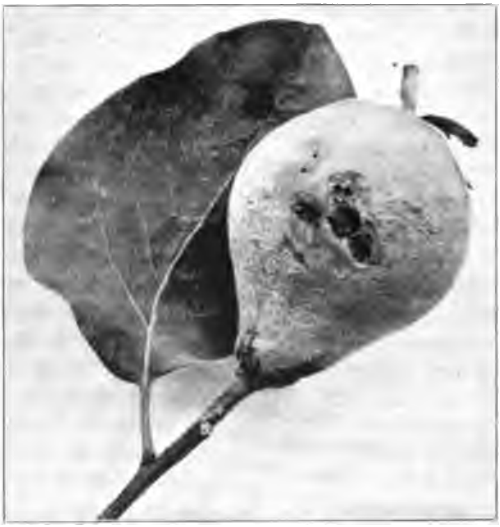
188.—*The plum curculio, enlarged.*



189.—*Grub of the quince curculio, enlarged and natural size.*



193.—*Sections through the egg-pits, showing the eggs in position; much enlarged.*



192.—*Young quince, showing the manner of feeding of the curculios.*

a prolongation of the head, but it is interesting and peculiar from the fact that the mouth-parts of the insect are out at the snout's tip, and the antennæ also arise from near the tip. As can be seen in the frontispiece, the antennæ can be neatly folded back for half their length in a little groove along the snout; the snout of the female is a little longer and less deeply striated than in the male. This peculiar situation of the eating apparatus renders the snout a very useful instrument for the quince curculio, but at the same time increases its destructive power. These points are discussed in detail in our story of the life and habits of the pest.

The grub or larva.—This stage of the insect is well shown, natural size and much enlarged, in figure 189.

It is a fleshy, maggot-like, footless grub of a semi-transparent, light flesh color. Its head is dark brown, with the horny jaws darker, and there is a lighter brown, shield-like area on the back of the first thoracic segment. The main trachea running along each side of the body shows quite distinctly through the skin (see the figure), and the pulsations of the "heart" can also be seen along the back. The spiracles are light brown in color, and the body bears a few brownish hairs.

This grub can be readily distinguished from the caterpillar of the codling-moth which also infests the quince, as the latter always has distinct legs.

ITS NAME.

This quince pest belongs to the largest and most important of the families—the *Curculionidæ*, or popularly, *curculios* or *weevils*—of the *snout-beetles*, of which more than a thousand different kinds are already known to occur in North America. This great family of curculios includes several of our most destructive insects, such as the acorn and nut-weevils, the well-known plum curculio, the strawberry weevil, and that recent importation from Mexico, the cotton-boll weevil.

When Walsh discovered and described the snout-beetle under discussion in 1863, he gave to it the scientific name, *Conotrach-*

elus crataegi, by which it is still known.* The first or generic part of the name is said to signify "conical thorax or throat," and *cratægi*, the specific name, was suggested by the fact that the insect was first found "swarming" on the common thorn, *Cratægus*.

Its very suggestive and expressive popular name of "quince curculio" was given to it by Dr. Trimble in 1870.

THE STORY OF THE LIFE AND HABITS OF THE QUINCE CURCULIO.

The quince curculio is so nearly related to the plum curculio† that one would naturally suppose that the stories of their lives would differ but little. However, careful observations have revealed some striking and important differences, thus again emphasizing the necessity for observations, rather than generalizations, upon the habits and lives of our insect enemies.

Its winter quarters.—It is in its grub stage (Fig. 189) that the quince curculio passes the winter. The long dreary months are spent by the grub in a little earthen cavity or cell two or three inches below the surface. After leaving the fruit in the fall, the grub burrows its way into the soil and there forms its winter home by rolling and twisting its body around and thus packing the earth back, leaving a small, oval, smooth-walled cell in which its winter nap is undisturbed by the elements above.

Its spring habits and transformations.—With the warmth of the spring-time the grubs begin their destined transformations necessary to complete their life cycle. Wonderful changes take place beneath the grub's skin which is finally cast off and a form, quite unlike the grub, known as the *pupa* appears. One of these yellowish-white, tender pupæ is shown much enlarged in figure 190. They are curious objects, with the developing legs, wings, snout and antennæ of the adult insect closely pressed against the body.

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*The insect was given the specific name of *humeralis* in Europe in 1837, but as no description accompanied this name, it cannot take the place of Walsh's name proposed 26 years later ; a Brazilian species of the same genus now bears the name of *humeralis*.

† Both bear the same generic or "sir-name" (*Conotrachelus*) and thus present only specific differences.

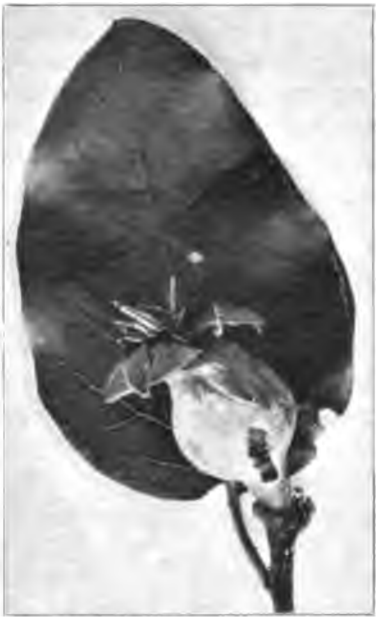
From 10 to 20 days are spent by this insect in the spring in this quiescent pupa stage in its earthen cell. Finally the pupal shroud or skin is cast off and the active adult or curculio appears. At first, the beetle is light colored and quite tender. On this account, it remains in the earthen cell for ten days or more, gradually acquiring its normal coloring and the maturity and hardness of body necessary to enable it to make its way through the soil to the surface to meet there the various vicissitudes of its life.

As some of the grubs go into the soil in August and the beetles which develop from them may not appear above ground before the middle of the next July, a quince curculio may spend eleven months of its life in the soil in the orchard. However, some of the grubs do not leave the fruit until much later in the fall, and in some years the spring climatic conditions are such as to hasten the development of the insect, so that the beetles sometimes appear as early as the latter part of May; thus only about seven months of its life may be spent in the ground.

In all our experience in rearing and observing insects, we never before met with one whose habits were so remarkably affected as were the quince curculio's by what was apparently simple variations in the climatic conditions in early spring. In 1896, the beetles appeared in full force on the quince trees at Geneva, N. Y., during the last week in May, when the quinces had reached the stage shown in figure 191. In April, 1897, Mr. R. A. Barnes, of Lockport, N. Y., kindly furnished us with many of the grubs undisturbed in their winter homes. Some of these were kept on our office table, but most of them were placed in another part of the insectary where they would be subject to out-door or more natural conditions. Those in our office developed into the beetles about June 1st, or practically on the schedule time of the preceding year in the orchards. But the grubs kept under natural conditions did not change to pupæ until the last week in June, and none of the curculios emerged in our cages until nearly a month later. Thinking that these results must be abnormal, due perhaps to some unknown and unnatural conditions in our cages, we at once wrote to Geneva and Lockport, asking that jarring experiments be made on a few trees to ascertain if the curculios were present in any numbers. Reports soon came from both places that the beetles were then out in full force ; the quinces had then attained the size shown in figure 192. At Geneva, they began jarring the trees in the latter part of May, or at the same time they caught the curculios the previous year, but soon stopped as practically none were found, and the jarring machines were laid aside with the belief that the pest would not need to be fought in 1897. It was very gratifying to have our breeding experiments thus verified in the field ; and the fact that the information thus gained enabled some of our largest quince growers to destroy hundreds of the curculios, which would otherwise have undoubtedly ruined many bushels of quinces, is a good illustration of the value of such experiments.

The explanation of the appearance of the curculios during the last week in July in 1897 and about May 26th, or two months earlier in 1896, is undoubtedly to be found in the difference in climatic conditions of early spring in the two years. From the report of the the New York State Weather Bureau we learn that " periods of abnormal warmth obtained during April andMay (1896), the maxima for the former month being among the highest recorded for April." The temperature conditions during a similar period in 1897, were nearly normal. Our breeding experiments with the grubs in a warm office and under normal out-door conditions, as detailed above, together with the known climatic conditions just mentioned, seem to afford conclusive evidence that the appearance of the curculios in the last week in May in 1896, was unusual and abnormal for the latitude of central New York It is unfortunate that our observations on this point do not extend over more than these two years, for it leaves it still somewhat uncertain at what time in the spring the curculios usually appear in New York. It is very doubtful if they often appear as early as June 1st, and we believe that the last week in July is unusually late ; probably their normal time for appearance is about July 15th, or possibly a little earlier in our State. Or the curculios probably do not appear on the trees until the quinces are somewhat larger than those shown in figure 191.

Habits of the curculios or beetles.—For a week or more after they emerge from the ground in the spring, the curculios feed upon the growing quince fruits, and possibly to a slight extent upon the leaves. The young fruits are covered with a thick fuzzy coating (in figure 191 a bit of this covering is loosened and turned back), but this offers little or no protection against the attacks of the beetles. While they seem to prefer to feed near the stem end of the fruit where the fuzzy coating is thinner, still they are often seen feeding at other points. In feeding, the curculio works its snout down through the fuzzy coating, eats a hole about the size of a common pin through the skin of the fruit, then proceeds to gouge out a pit or hole, often about the size of a half pea, in the flesh just beneath the skin; its curved snout with the jaws at its end, is well adapted for this work. In figure 192, the skin has been removed to show several of these holes made by the curculios in feeding. Just to the left of these large holes the fuzzy coating was scraped away to show two little holes eaten through the skin, which lead into similar large pits in the flesh. When we saw the beetles feeding in May, 1896, the fuzzy covering was quite thick (Fig. 191), and when the beetle withdrew its snout, the coating closed up, entirely obscuring the hole in the skin, so that it was impossible in many cases to determine if a fruit had been eaten without first scraping off this fuzzy covering. Oftentimes the constricted portion of the fruit near the stem will be riddled with holes where the curculios have fed.



191.—*Young quince, with small flap of the thick fuzzy coating of the skin turned back.*

We have no positive evidence, but our observations indicate that the pits and hard kernels which are so familiar to quince growers in the "knotty" fruits, are the direct result of the feeding habits of the curculio. We believe the holes thus made in the skin and fruit when it is small, finally result in the "knots" of the mature fruit. If this be true, the insect injures the market value of the fruits quite as much in its curculio or beetle stage as it does later as a grub.

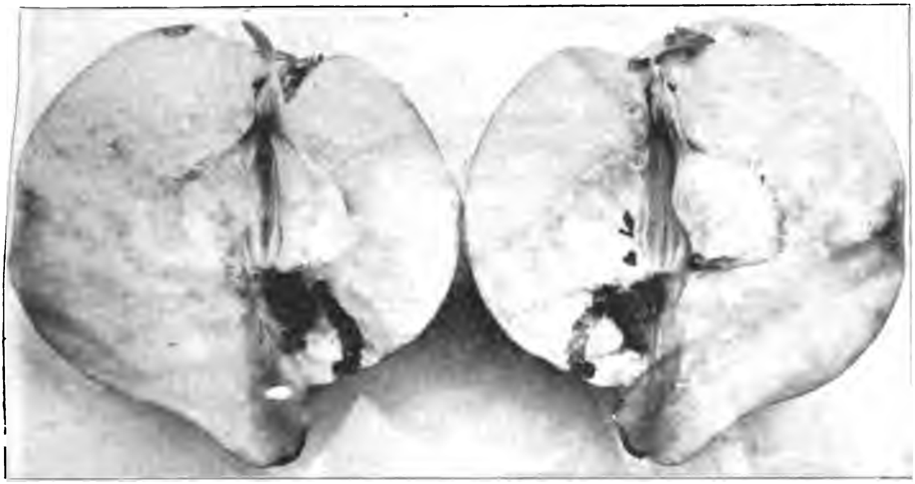
Egg-laying.—After feeding on the fruit for about a week, as described above, the beetles copulate and soon begin laying eggs. In 1896, the eggs must have been laid early in June, while in 1897, egg-laying did not take place until early in August. The eggs are laid in little pits made by the mother beetles in the fruit. A small hole is first eaten through the skin and then a pit about the size of a half pea is gouged out of the flesh. These pits thus made are indistinguishable from the ones made by the beetles in feeding, so that it is impossible to tell on the surface of a fruit whether the pin-holes through the skin lead into egg-chambers or feeding-pits. In figure 193 are shown sections through two egg-chambers. It will be seen that the pits are considerably larger than the eggs, and are irregular in shape. After eating out the pit with her snout, the mother beetle doubtless simply turns around and deposits the egg through the hole in the skin, perhaps then pushing it down to the bottom of the pit with her snout. This completes the operation, there being no crescent cut made as in the case of its near relative, the plum curculio.

The quince curculio's egg is of a semi-transparent, whitish color, and of the form shown in figure 193. It measures .56 mm. in diameter and is .9 mm. long. Under low magnifying powers, the shell of the egg appears smooth, but when greatly magnified, the whole surface is seen to be finely reticulated with ridges which outline small, four to six-sided areas. The egg seems to have a harder or thicker shell than that of the plum curculio, for it is certainly less easily crushed. This fact and the fact that the quince fruit grows comparatively slower than the plum may explain why the quince curculio finds it unnecessary to make any crescent cut to prevent its egg from being crushed by the growth of the fruit.

Evidently the egg-laying period of the beetles is of considerable duration. We examined the ovaries of one curculio soon after she had begun to lay her eggs, and found therein many eggs as yet only partially developed. We were able to count nearly thirty eggs in all stages of development in the ovaries of the beetle examined. Thus, thirty is doubtless approximately the number of eggs which each curculio lays, and probably two weeks or more elapse before this full quota is laid.

In August, 1897, the eggs hatched in from seven to ten days, and the little grubs at once began eating their way into the fruit.

Habits of the grubs.—The grubs continue feeding in the fleshy part of the fruit for about a month, forming therein a large "worm-eaten" cavity, as shown in figure 194. They usually do not extend their operations into the core of the fruit, as does the codling-moth caterpillar. When full grown, the grubs eat their way to the surface of the fruit, forming the familiar "worm-hole" leading into the blackish, disgusting-looking cavity in the flesh.



194.—*A "wormy" quince cut open.*

Usually most of the "wormy" fruits remain hanging on the tree, and it is often impossible to distinguish them until the grub makes its exit through the tell-tale "worm-hole." If the fruit falls to the ground before the grub is full grown, it continues feeding in the fallen fruit until full-fed or the fruit rots. In one instance it is reported that one-twentieth of the infested fruit dropped, the grubs continuing therein until the fruit decayed. As many as six of these grubs have been found infesting a single quince.

The grubs doubtless drop to the ground upon leaving the fruit which remains on the tree, and they soon burrow into the soil for a distance of from one to three inches ; those grubs which mature in the fallen fruit, also leave it and enter the soil. During normal seasons, some of the grubs doubtless leave the fruit in August ; but often many of them are still in the fruit when it is picked and, upon emerging, find themselves in the packing-case or barrel. In 1897, some of them were still in the fruit on the trees on October 4th. Thus the grubs may be found in the fruits at any time after July, and sometimes even in June. However, there is but one brood of the grubs in a season or year ; for it matters not if some of them get full grown and enter the soil early in August, because these, as well as those which do not leave the fruit until October, all remain unchanged in the soil throughout the winter in a little earthen cell, as described in discussing its winter quarters.

NATURAL ENEMIES.

We have found no record of any natural enemy attacking this quince curculio in any of its stages. However, such an enemy is at work upon the curculios in New York. Among the grubs sent us in April, 1897, was one which behaved unnaturally, not burrowing back into the soil when disturbed as did the others. A few days later, the cause of this was revealed, when in the place of the grub we found a neat little cocoon lying beside the head and skin of the grub. This was on April 26th, and 18 days later there emerged from this cocoon a pretty little hymenopterous fly which bears the scientific name of *Sigalphus canadensis*. This little friend occurs in widely separated portions of America, and has been bred from other curculios or weevils. In Iowa, where it is parasitic upon the plum gouger, it is thought that the little fly sticks its egg through the flesh of the plum into the cavity where the grub is at work and the grub succumbs before it leaves the fruit. We have no data as to how the parasitism is accomplished in the case of the quince curculio in New York; evidently, however, the grub sometimes gets into the ground before succumbing. Probably, at present, this parasite exercises but little influence in controlling the numbers of the curculio in New York.

HOW TO COMBAT THE QUINCE CURCULIO.

It will require much intelligent and well-directed effort on the part of the quince-grower to circumvent this curculio, but it can be done, as some of our fruit-growers are demonstrating. While we have conducted no experiments against the insect personally, we have had the direction of the warfare in some of the larger quince orchards, and have been fortunate in having the experience of successful growers placed at our disposal.

The fact that the eggs are laid in pits in the flesh beneath the skin of the fruit (Fig. 193) renders it practically impossible to reach the insect in this stage with any insecticide, or by any other practicable method. Also, when the eggs hatch the young grubs are inside the fruit, practically as fully out of the reach of insecticidal measures as are the eggs. The only chance to reach any of the grubs while in the fruit is to gather up and destroy at once the comparatively small proportion of the infested fruits which fall to the ground before the grubs leave them. It is often very difficult to determine, without mutilating it, if a quince is infested while it still remains on the tree, so that the picking off and destroying infested fruit is not practicable; after the grub leaves the fruit, making its familiar "worm-hole" exit, infested fruit is easily distinguished, but then "the bird has flown."

Cultivation of the soil.—The fact that the grubs leave the fruits, enter the ground a short distance, and there remain for many months, has led several writers to recommend that a thorough cultivation of the soil, either in the fall or spring, would disturb and destroy many of the grubs. Theoretically this should prove an effective remedial measure. But the experience of some of our largest and most successful quince growers who have cultivated their orchards thoroughly, both in the fall and spring, for several years, proves quite conclusively that cultivation has but little, if any, effect in reducing the numbers of the curculio.

We were unable to understand the reason for this until we saw the grubs do a very simple thing in our breeding cages here at the insectary in April, 1897. Mr. R. A. Barnes, of Lockport, N. Y., had kindly sent us a lot of soil, from his quince orchard, in which there were many of the grubs undisturbed in their earthen cells made the fall before. We broke into these winter cells or homes and removed the apparently inactive or dormant grubs and placed them on the surface of some other soil in our cages, intending to cover them with soil later. What was our surprise a few minutes later to discover that the grubs had waked up from their winter's nap and had disappeared. Investigation later showed that they had burrowed into the soil and formed another earthen cell, just as they had done the previous fall. Hence our thorough breaking up of the soil, resulting in their being subjected to practically similar, or even more adverse conditions than would result from cultivation, had not even discouraged the grubs. We disturbed in a similar manner some of the grubs several times, and always with the same result that they quickly burrowed into the soil again. We believe, therefore, that the non-success of cultivation either in the fall or spring, as demonstrated in practice in several badly infested orchards, is due principally to the fact that the grubs simply burrow back into the soil, however often they may be disturbed.

In 1897, one large infested quince orchard was plowed in January to a depth of three or four inches; the ground was bare and it froze very soon after plowing. During the latter part of March and early in April, this orchard was thoroughly cultivated, and the cultivation continued later in the season. Yet, in spite of this, hundreds of the quince curculios were captured on the trees in August. Thus cultivation cannot be depended upon to check this pest, while in its grub stage in the soil, either in the fall or spring.

Theoretically, however, thorough and rather deep cultivation at the time the insect is passing through its tender pupa stage in the soil, should destroy many of these pupæ. Probably, during normal seasons, the pupa stage is passed in the latter half of June or early in July. We have no definite data as to the effect of deep thorough cultivation at this time or at this critical period in the life of the pest, except the general statement of quince growers who are considered good cultivators of their orchards, that they can see no effect from it upon the numbers of the insect.

Spraying.—Until within a few years, nearly everyone who has made any serious attempt to control this pest, has used a poison spray for this purpose. As a perusal of our story of its life will show, the only stage of the pest that could be reached by a poison, is the curculio or beetle; the grub is inside the fruit, out of harm's way, from the moment it hatches from the egg. The only chance to poison the beetles is during the week or more which they spend in feeding on the fruit, previous to and during the period of egg-laying. Although the beetles are quite ravenous eaters, their method of feeding, as described on page 703 and illustrated in figure 192, will at once show how little chance there is to poison them. Most of their food they get from beneath the skin in the flesh, only eating a minute hole through the skin.

Theoretically then, the chances for poisoning the quince curculio are small. Fortunately for the theory, it is the universal testimony of quince growers who have thoroughly tested the arsenical sprays, London purple and Paris green, against this pest that they have been able to see little or no benefit from spraying. One large grower after faithfully spraying with poison for several years without success, became so discouraged as to seriously consider uprooting his trees.

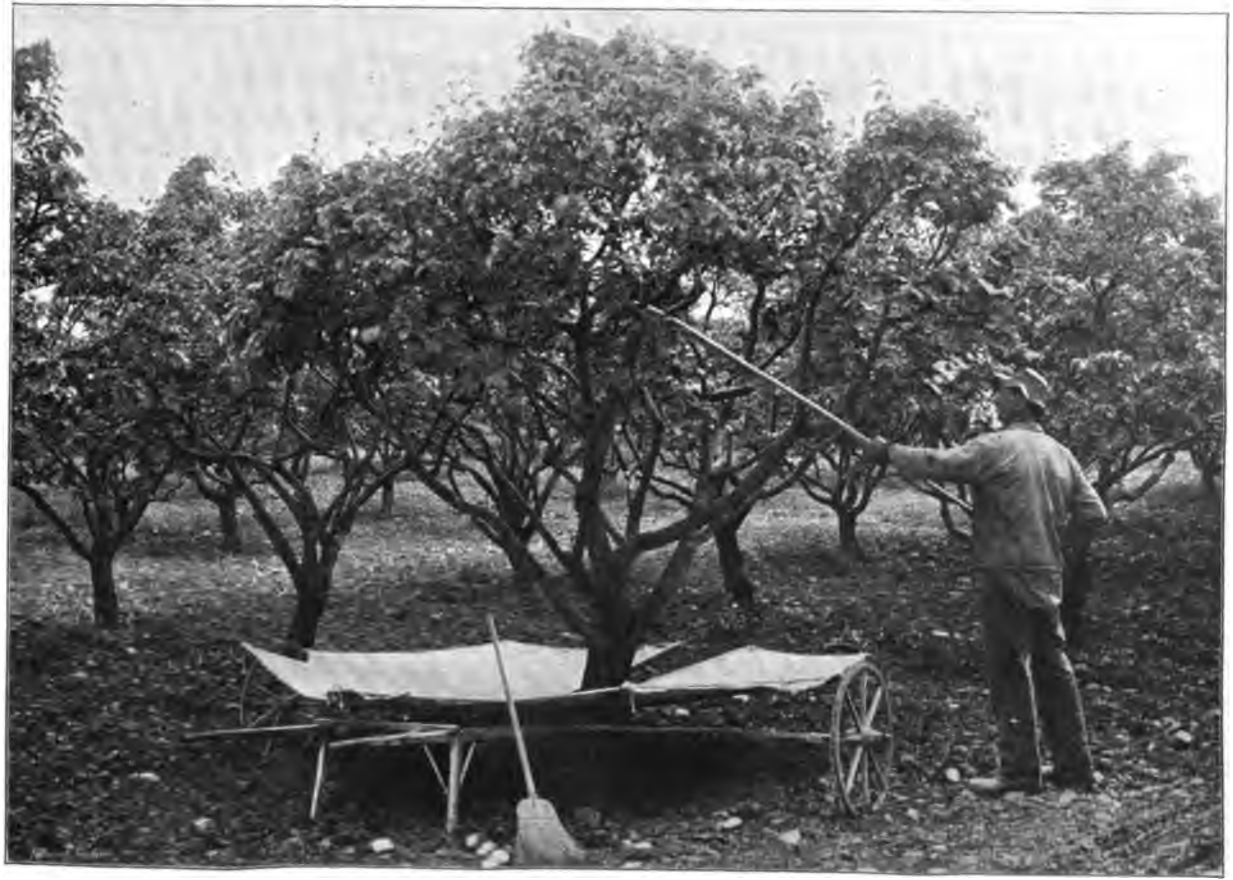
Applications to the soil.—We doubt if the application of any substance to the soil in practicable quantities would destroy enough grubs to pay for the trouble of applying it.

Hogs in the orchard.—In one quince orchard, Mr. R. A. Barnes, of Lockport, N. Y., "allowed hogs to run from early in the spring until just before time to gather the fruit when, because they would reach up and pick the fruit, they were excluded for a time;" small grain was from time to time scattered on the ground to induce more thorough "rooting" by the hogs. From this orchard, he gathered his finest fruit. Either the orchard was not badly infested by the insect, or else the hogs found most of the grubs in the spring before they transformed into the beetles.

Jarring method.—Like the plum curculio, this quince curculio quickly drops to the ground when the tree is *jarred*, not *shaken*. This habit of the insect seems to be its most vulnerable point; and it is undoubtedly the point against which the most successful attacks can, with our present knowledge, be made by quince-growers. The process of jarring is very simple and is too familiar to need description here. Nearly every fruit-grower who practices. it has his favorite padded "jarring-pole" and there are several kinds of receptacles in use for catching the curculios when they drop. These "curculio-catchers" vary in design from a simple sheet of cloth stretched on a wooden frame (to be held by the operator with the aid of straps over the shoulders or to be simply laid on the ground) to elaborate wheelbarrow-like machines carrying a canvas arranged like an inverted umbrella, as shown in figure 195.

It is a much more difficult matter to jar quince trees than it is plum trees on account of their great difference in habit of growth. The main branches of the quince often start from very near the ground, thus making the trees so low that it would be impossible to work one of the ordinary "wheelbarrow catchers" under them. This compels one to use simple sheets or to do as one large grower did, prune up the trees and have a cart built especially low. Figure 195 is from a photograph taken in this orchard and shows this low form of "curculio-catcher" built to order for fighting this pest. It was this orchard which the owners thought seriously of uprooting (as mentioned above under spraying) on account of this curculio, but thorough work with these jarring machines for a few years has made it a very profitable orchard again; the pest has not been exterminated, and it is still necessary to keep an eye on the insect. Thus, with our present knowledge of its life and habits, the jarring process is the most successful method for fighting the quince curculio yet suggested and tested.

Some of the curculios are to be found on the trees at any time during the day or night. It is said to be more active at night and rather secretive during the day, perhaps sometimes hiding in the crevices of the bark or in grass or soil at the base of the tree.



195.—*Jarring for the quince curculio with a low "curculio catcher" designed especially for the work.*

We have made no observations upon this point. Those who practice the jarring method begin the work early in the morning and continue it all day, if necessary.

The more important question, as to just when to begin jarring for this pest, we are unfortunately unable to set any definite date. In 1896, the beetles were out in force in the last week of May when the quinces were of the size shown in figure 191, while in 1897, they did not appear until the last week in July when the fruits were as large as the one shown in figure 192. We have offered an explanation for this remarkable difference of two months in the date of appearance, in our discussion of the life-story of the pest. In 1897, one large grower began jarring in the latter part of May expecting to capture the curcutios as he had done at this time the year before, but finding no insects, he put away his machines, thinking there would be none to trouble his fruit. We notified him when the beetles began to emerge in our cages in the latter part of July, and he got out his machines again and found the enemy this time.

We believe, however, that 1896 was quite an abnormal year, and that the curculios will not often appear so early as the last week in May. On the other hand, we suspect that the last week in July is uncommonly late for their appearance. In the latitude of St. Louis, the curculios appear about June 1st, and we believe that they normally appear in New York state about July 15, perhaps a little earlier. However, this is not a matter for the quince grower to guess at, and there are two ways open for him to find out about when to look for the beetles. It will be a simple matter to spade up some soil in the orchard in April, examine it carefully to make sure it contains some of the grubs in their earthen cells, and then put the soil in a box or can of some sort whose top can be covered with netting. Keep the soil moist, and await developments. In short, start an experiment in breeding the insect. Nothing will interest your children more than a simple experiment of this kind. When you find that the beetles have emerged from the soil in your cage, then get out the jarring machines.

A second method of determining when the beetles are at work is to begin in the latter part of May and jar a few trees every day. It will be an easy matter to discover just when to turn loose the rest of your batteries upon the enemy.

Those who practice the jarring method successfully, jar the trees every day, if possible, from the time the beetles appear until their numbers decrease beyond the danger point, or only a few are captured each time. In one orchard in 1897, 200 curculios were jarred from seven trees, and it was not an uncommon thing to get nearly 50 beetles from a single tree at one jarring when they were the most numerous. Usually it will not be necessary to jar the trees for more than six or eight weeks, often less.

This jarring process involves considerable labor and expense, but experienced fruit growers tell us it costs only from 15 to 20 cents to jar a tree during the season. One should consider that this slight expenditure may often favorably decide the important question of a large crop of fine fruit or a meagre crop of "knotty" and "wormy" fruit. Fruit growers and others who have insect foes to fight do not often think of this phase of the question when considering the expense which a certain method may involve.

After you capture the curculios with your jarring device, then exercise your own ingenuity in killing them. Some put them in kerosene or boiling water, while others have a charcoal stove built for the purpose, into which everything that falls onto the sheet is burned.

MARK VERNON SLINGERLAND.

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Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

CHEMICAL DIVISION.

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A PRELIMINARY REPORT ON THEIR
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By GEO. W. CAVANAUGH.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

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SOME SPRAYING MIXTURES.

Since spraying has taken its place as a part of the routine work connected with the fruit farm, much attention has been given to the substances used for spraying. The results of many trials with various materials have been published in the bulletins from the different stations, and now special spray calendars are issued by some stations. Bulletin 114 of this Station is a spray calendar.

Among the standard remedies for chewing insects are Paris green, London purple and hellebore, while the Bordeaux mixture, ammoniacal copper carbonate, liver of sulphur, etc., are recommended for fungus diseases, blights, and mildews.

Paris green is composed of copper, acetic acid, and arsenous oxide, and when pure should contain at least fifty per cent of arsenous oxide. Arsenous oxide is the chemical name for white arsenic.

Five samples of Paris green recently examined at this laboratory contained :

I = 54.63 per cent arsenic.
II = 54.47 " "
III = 54.32 " "
IV = 55.32 " "
V = 54.90 " "

London purple is a waste product in the manufacture of some dye stuffs and consists chiefly of arsenic lime, and the dye. Paris purple and English purple are quite similar in character to London purple.

A sample of English purple gave on analysis :

Arsenic (As_2O_3)..............................36.75 per cent.
" " soluble in water.......... ... 5.36 "

Paris Purple.		Total.	Soluble in water.
No. I.	Arsenic (As_2O_3)...........	47.05	11.86
No. II.	" "	34.10	13.88

The arsenic is here combined with lime. When any of the purples are used as insecticides, two or three times their weight of quick lime should be used to counteract the effect of the arsenic soluble in water.

During the past few years various substitutes for the arsenical poisons have been on the market. In 1888 the Vermont Station published the analysis of slug shot.

Arsenic (As_2O_3)	1.58 per cent.
Copper oxide	.60 per cent.

A sample recently examined at this Station contained:

Arsenic (As_2O_3)	.60 per cent.
Copper	1.15 per cent.

The Massachusetts State Station in 1893 examined several insecticides and among others found the Oriental Fertilizer and Bug Destroyer to contain 2.38 per cent arsenic.

During the present season a number of inquiries have been received at this Station concerning insecticides and fungicides. As it is too soon to give results of actual trials, only the chemical composition of the substances can be given, which the reader may compare with the older insecticides and fungicides.

LAUREL GREEN.

A new preparation under the name of Laurel Green, is on the market and is offered for sale as a substitute for Paris green. It also claims virtue as a fungicide. A chemical analysis shows it to contain arsenic, copper and lime and sulphuric and carbonic acids. These same substances would be found in a mixture of Paris green and Bordeaux mixture after drying. The copper and arsenic were determined.

Copper (Cu)	10.00 per cent.
Arsenic (As_2O_3)	7.75 per cent.

BUG DEATH.

While it may be possible to combine both insecticidal and fungicidal properties in the same compound, there may be some doubt about the economy of depending on such preparations to act as fertilizers also. Nevertheless in the advertising matter accompanying a sample of Bug Death, the following statement is made:

"I will undertake to guarantee it, as not only is it a fungicide and insecticide, but as well, it acts as a fertilizer. It is sure death to all the tribe of bugs from A to Z and it will prevent potato blight, tomato rot, melon disease, and strawberry-leaf blight—all of which diseases are formidable in the northern and eastern states. Bug Death is a tenacious powder, and wherever it takes hold it serves its purpose."

W. H. MORSE, M. D., F. S. S.,
Consulting Chemist.

WESTFIELD, N. J., April, 25, 1898.

It contains neither arsenic nor copper and what its value rests upon it is difficult to see, for it consists principally of zinc, lead and iron oxides, in the following proportions:

Zinc oxide	76.5%
Lead oxide	9.8
Iron oxide	7.8

The remainder consisted of silica, chlorine, potash and a trace of phosphoric acid. While it may prove useful in combating some pests, there is not, I believe, any record of the use of oxides of iron, zinc or lead as successful insecticides.

The consulting chemist above mentioned claims fertilizing value for Bug Death.

A fertilizer analysis gave the following results:

Nitrogen	.00%
Phosphoric acid	.08
Potash	2.00

The average of analyses of five samples of soil of ordinary productivity was found to be:

Nitrogen	.21%
Phosphoric acid	.16
Potash	1.63

Inasmuch as Paris green must now contain 50 per cent of arsenic when warranted to be pure, other arsenical compounds whose insecticidal value depends on the arsenic should be sold on a comparative basis. When users of spraying mixtures demand that the goods bought be of a certain quality the supply will be forthcoming, as it was in the case of commercial fertilizers.

GEO. W. CAVANAUGH.

THE FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION TO THOSE WHO MAY DESIRE THEM.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf-Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N.Y., 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western N. Y., 27 pp.
81 Black Knot of Plums and Cherries, 24 pp.
82 Experiments with Tuberculin, 20 pp.
84 The Recent Apple Failures in N. Y., 24 pp.
87 Dwarf Lima Beans, 24 pp.
92 Feeding Fat to Cows, 15 pp.
93 Cigar- Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
97 Entomogenous Fungi, 42 pp.
100 Evaporated Raspberries in New York, 40 pp.
101 The Spraying of Trees and the Canker Worm, 24 pp.
102 General Observations in Care of Fruit Trees, 26 pp.
103 Soil Depletion in Respect to the Care of Fruit Trees, 21 pp.
104 Climbing Cutworms in Western N. Y. 51 pp.
105 Test of Cream Separators, 18 pp.
106 Revised Opinion of the Japanese Plums, 30 pp.
107 Wireworms and the Bud Moth, 34 pp.
109 Geological History of the Chautauqua Grape Belt, 36 pp.
110 Extension Work in Horticulture, 42 pp.
114 Spraying Calendar.
116 Dwarf Apples, 31 pp.
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119 Texture of the Soil, 8 pp.
120 Moisture of the Soil and Its Conservation, 24 pp.
121 Suggestions for Planting Shrubbery, 30 pp.
122 Second Report upon Extension Work in Horticulture, 36 pp.
123 Green Fruit Worms, 17 pp.
124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp
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129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
132 Notes upon Celery, 34 pp.
133 The Army-Worm in New York, 28 pp.
134 Strawberries under Glass, 10 pp.
135 Forage Crops, 28 pp.
136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1897.

138. Studies and Illustrations of Mushrooms: I.
139. Third Report upon Japanese Plums.
140. Second Report on Potato Culture.
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142. The Codling-Moth.
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145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.
148. The Quince Curculio.
149. Some Spraying Mixtures.

Bulletin 150. **July, 1898.**

Cornell University Agricultural Experiment Station,
ITHACA, N. Y.
VETERINARY DIVISION.

Tuberculosis in Cattle and its Control.

NEW YORK STATE VETERINARY COLLEGE.

By JAMES LAW.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

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TUBERCULOSIS IN CATTLE AND ITS CONTROL.

BY JAMES LAW.

PREVALENCE AND RELATIVE IMPORTANCE.

Our interest in tuberculosis centers in two leading questions: First, its prevalence in man; and second, its diffusion among domestic animals which furnish food for man. If we consider the disease in man only, we must view it first in its sanitary relations, and, as regards the measures available for its restriction, in its moral bearings. If we consider the disease in the domestic animals we enter largely into its economic bearing, but in view of the use of these animals and their products for human food the sanitary and moral questions must also be admitted.

MAN: GENERAL MORTALITY.

In man it is admitted that, in civilized countries, where data can be secured, one death in seven is due to tuberculosis. Allowing 15 deaths per 1,000 on our 70,000,000, this would furnish 150,000 deaths per annum from tuberculosis in the United States. Dr. Osler, of Johns Hopkins University, says this is a very low estimate. A war which should leave 150,000 dead on the battle field every year would rouse the nation to put a speedy end to the destruction. The mortality from tuberculosis exceeds the combined deaths from war, famine, plague, cholera, yellow fever and smallpox. Yet we have those among us who deprecate any intelligent measure for the extinction or restriction of this source of such a constant mortality and loss.

The mortality from tuberculosis in man rises far above this ratio when conditions are favorable to its propagation. In some large cities (Vienna) the ratio of deaths from tuberculosis is more than double what it is for the entire country. In the Marquesas

Islands it rises to 33 per cent of the total mortality, and in some of our Indian reservations to 50 per cent. (Treon, Holden.)

TUBERCULOSIS IN ANIMALS.

Tuberculosis is rare in cold blooded animals, but Sibley has seen it in *reptiles* in a state of confinement.

In *birds* it is common and destructive, but not readily transferred from bird to mammal. The bacillus of the bird is usually a modified form, which prefers a special avian habitation.

Wild mammals in confinement suffer excessively. In menageries apes die almost exclusively from tuberculosis, while kangaroos, deer, elk, gazelle, antelope and lions are common victims. The rats, mice and other vermin about our houses and barns also contract the disease and all must be recognized as possible bearers.

Cattle suffer more than any other domesticated animal, and tuberculous cattle are especially to be dreaded seeing that they furnish so much food for consumption by man. The Danish herds which were said to be sound until after the importation of Schleswig and Shorthorn cattle in 1840 and 1850 are now generally infected, 17 per cent of the cattle slaughtered showing tuberculosis, while over 60 per cent of the dairy herds showed the disease under the tuberculin test. Statistics from German abattoirs give, for cows 6.9 per cent tuberculosis, for oxen 3.6 per cent, for bulls 2.6 per cent, and for yearlings and calves 1 per cent. In Berlin abattoirs 15 per cent proved tuberculous. By the tuberculin test of New York State herds (2,417 head) in 1894 16.75 per cent proved tuberculous. This is undoubtedly too high an estimate for the entire cattle of the State, as the herds were examined because the owners suspected them and requested examination by the tuberculosis commission. Yet it cannot be said that this represents the extreme of infection as I have found one herd of 60 and another of 200 in country districts of this state tuberculous without exeeption. These represented cases in which no precaution had been taken to prevent contagion.

Swine are also very subject to tuberculosis, especially through the consumption of the uncooked offal of slaughter houses and of the milk of tuberculous cattle.

Rats and mice readily contract the disease from feeding in the mangers of tuberculous cattle and swine, and in their turn carry the disease from manger to manger and from barn to barn.

Rabbits, Guinea pigs and goats when left at large do not readily contract the disease but are very susceptible to the infection when it is conveyed to them experimentally.

Horses, asses, dogs, cats and sheep do not readily contract the disease under ordinary circumstances, but this cannot be attributed mainly to insusceptibility since one and all take it easily when inoculated. The habitual immunity is therefore largely due to the absence of opportunity for infection, and in some degree also to the outdoor life and the well developed state of the muscular system and blood. For the house dog and cat infection has often come from eating scraps from the plate of tuberculous people and in some instances from licking up the expectoration. At Alfort only 40 dogs were found tuberculous in 9,000 *post mortem* examinations.

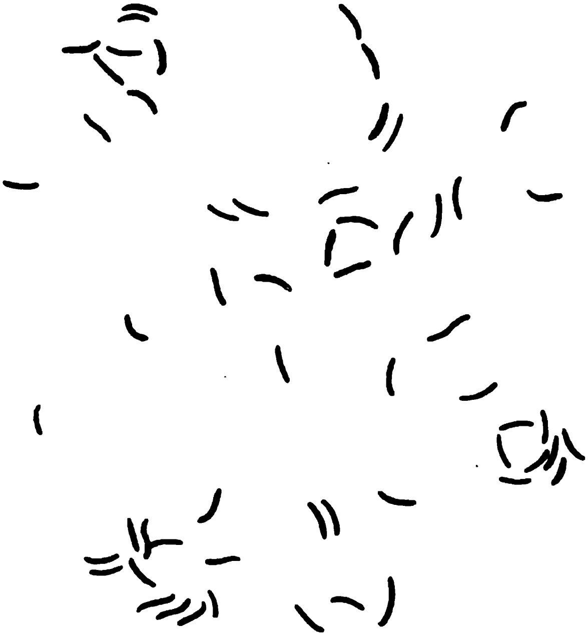
TUBERCULOSIS CONTAGIOUS.

That this disease is contagious was recognized by many of the medical lights of the 16th to the 18th centuries. Morgagni, Læennec, Cullen, Wickman, Valsalvi and Sarconi, and for animals, Ruhling, Krunitz, Fromage, Huzard and others leave evidence corroborating this belief. The civil and ecclesiastical laws joined in forbidding the use of the meat from tuberculous animals, and in prescribing the destruction or disinfection of articles that might have become infected from tuberculous persons.

This was placed on a solid basis by the many successful experimental inoculations of the disease by Villemin in 1865 and by his numerous followers, who conveyed the disease by feeding tuberculous matter, and by causing the animals to inhale tuberculous liquid in the form of spray. Finally, Robert Koch, of Berlin, completed the demonstration, placing the keystone in the great arch of evidence, by the discovery of the tubercle bacillus, which he invariably found in the diseased tissues and in no others, and which he cultivated in pure culture in glycerine bouillon, and inoculated successfully upon a large number of animals.

Since that time (1882) his position has been corroborated by all competent observers, and there is no truth in medicine more thoroughly established to-day than the essential connection between tuberculosis and the tubercle bacillus. This bacillus has been so often conveyed with destructive effect from man to the smaller mammals, and even to cattle, that the essential identity of human and bovine tuberculosis must be accepted. This statement requires the qualification that the bacillus, like other pathogenic germs, adapts itself to the conditions of the medium on which it grows, and therefore, in the first place to the particular genus of animals in which it has been living for some time, and is therefore often less ready to grow in one of another kind

Fig 1.



1.—*A drawing from a preparation of tubercle bacilli magnified about 1000 diameters.*

than in one of the same genus. The most extreme example of this is found in the bacillus of the bird which can only with difficulty be made to grow in the system of the mammal.

But even in the mammal the virulence of the bacillus for other mammals of a different genus or species may be very varied.

Theobald Smith obtained, from a pet bear that had been owned by a tuberculous master, bacilli which seemed to have no ill effect when inoculated on cattle, and had a somewhat reduced virulence for Guinea pigs. Kruse found bacilli from human sputum, and others from the lungs of cattle which produced only local tubercle in Guinea pigs.

Clinical observations show that the same is true as between different individuals of the same genus and species, and hence we find instances of tuberculosis in given herds, which continue for a number of years with few cases showing generalized and fatal results; and other instances of herds in which the disease makes rapid progress, soon affecting all or nearly all of the animals, and proving fatal to a number in rapid succcession.

This modification of the germ by its surroundings is again well shown in the common experience that it is usually difficult to start (on artificial media in flasks) the growth of tubercle bacilli taken direct from the animal, but when once started and accustomed to grow on such new materials, it may be started again in fresh culture with great certainty.

In stating, therefore, that the one and only cause of tuberculosis is the tubercle bacillus, it is not to be understood that it is affirmed that that bacillus is at all times, under all circumstances and to all animals, equally virulent and destructive. If the conditions are favorable it will prove very deadly, while, if unfavorable, it may linger for a time without producing much obvious effect on the general health. Its presence, however, in any herd is a constant menace to all members of the herd, to the attendants, to the consumers of the meat and dairy products of the herd, and to other herds into which members of this herd may be sent. It is also worthy of note, that the power of adaptation of the germ to its surroundings, introduces this further element of danger that, as it becomes adapted to its life in a given animal or in the different members of a closely bred herd, in the natural course of events it must become better and better adapted to survival in that particular animal and breed, and hence increasingly dangerous to all of its members. This is one reason why tuberculosis is so liable to become intensified in special herds of thoroughbred stock, and why common cattle with a varied ancestry will sometimes seem to offer a longer resistance to the affection. It may also explain the fact that with ample exposure the disease does not always pass from men to cattle and from cattle to man.

Yet it would be folly to argue from such data that the disease, when present in an occult form in a herd, may be safely ignored, and that the products of such herd may be safely consumed by man. The very adaptability of the tubercle bacillus sufficiently contradicts this conclusion. The mere continuous presence of the bacillus in a given system, human or brute, is the means of securing a better and still better adaptation to that form of life, and a greater and still greater measure of potency, so that when the health of the host or exposed animal is in any way reduced it may at once become deadly and far reaching in its evil effects.

CHANNELS OF INFECTION.

Among the channels of infection the following may be noted :

1. *Inhalation by the breath.* This is perhaps the most common method of infection and is usually followed by tuberculosis of the throat, lungs, and lymphatic glands of the chest. Expectorations and other infecting discharges are dried up and raised in dust so that they can be easily inhaled. Cases of this kind have been observed in buildings in which a victim of advanced tuberculosis was employed. The other employes fell victims, one after another, to the infection. They are quite common in infected barns, in which the virulent dust carried in the air is inhaled by a number of animals. Experimentally it has been shown by mixing virulent matters in liquids, atomizing them and causing animals to inhale the spray. In the hands of Villemin, Koch, Thaon and Tappeiner this almost infallibly produced tuberculosis of the lungs. In man too, many infections and reinfections have been traced to the dust from the soiled handkerchiefs. On the other hand it must be distinctly understood that

the breath of the tuberculous is not in itself infecting, and if care is taken to prevent the diffusion of the infected solids and liquids and their distribution in dust, the presence of a tuberculous individual is not a threat to others adjacent.

2. *Infection through food and drink.* A whole host of experimenters have conveyed the disease by mixing infecting pus or an emulsion of the tubercle with ordinary food. The same has been often accomplished with milk from the infected animal even to cases in which the mammary glands seemed to be perfectly sound. The danger of course is enhanced in ratio with the number of bacilli present, so that one diseased cow in a large herd leads to little infection if the milk of the whole herd is mixed. On the other hand such admixture of the virulent milk with the wholesome contaminates the whole to some extent, and inoculation with such mixed milk will often convey the disease when the animals drinking it do not seem to be injured by it.

The infection usually takes place through the tonsils, pharynx or bowels. In ruminating animals it may attack the first three stomachs the contents of which are neutral or nearly so, but it rarely attacks the true digesting stomach the secretion of which is strongly acid. The bacillus is liable to perish or to be so distributed by the acid in passing through the stomach that it is largely shorn of its danger. Among the conditions that favor its safe passage through the stomach may be named indigestion and a too rapid progress of the undigested food through the stomach, a condition which is especially common in young animals: overloading of the stomach: the ingestion of an excess of cold water just after a meal, thereby rousing excessive vermicular movement of the stomach and premature expulsion of its undigested contents: and the enclosure of the infected matter in a mass of fat which the gastric secretions are impotent to digest or emulsionize.

3. *Inoculation in wounds.* This is a common channel of infection in man. Accidental inoculations—in making post mortem examinations have been often noticed since the case of Læennec ; or in making artificial cultures in the laboratory ; or in washing the clothes of tuberculous persons ; or in dressing the tuberculous sores ; or in making operations, notably that of

circumcision; or in inserting earrings formerly used by tuberculous persons; or in inhaling the infecting dust through a nose excoriated by a catarrh; or in handling infected carcasses in the butcher's shops; or finally through mouth or throat abrasions caused by hard indigestible materials.

4. *Through the mammary glands.* This gland is especially subject to wounds by the horns and to sores and abrasions in connection with milking which form entrance-channels for the bacilli present in the dust of the barn. The opening of the teat is also a door of entry through which the germ may invade the milk ducts and glandular tissue. It is not to be forgotten, however, that the milk gland is especially liable to become infected through the blood which is sent in such enormous quantities through its tissues, and is liable to implant any bacilli which may have entered the blood stream. The gland is, therefore, especially liable to infection from without and within and once infected is a source of the greatest danger to the milk consumer.

5. *Through sexual congress.* In cows the generative organs are often the seat of tuberculosis inducing nymphomania or sterility, and the disease has been repeatedly produced experimentally by smearing the infecting matter on the penis or introducing it into the vagina. The bacillus has even been found in the semen of an infected male so that transmission by this channel to the female can be easily understood. All this has a very direct bearing upon the question of the propriety of using the same sire on the tuberculous and sound, and of the admission of females from tuberculous herds to be served by the sires in sound ones.

6. *Through heredity.* Hereditary transmission of tuberculosis has long been recognized, and until recently accorded a rôle much more important than its infrequency would warrant. Various conditions militate against its occurrence; the fœtus is essentially a carnivorous animal, living on the secretions of the dam and not on the direct products of the vegetable kingdom. It has, therefore, that measure of resistance which inheres in the flesh feeding as compared with the vegetable feeding animal. It may be infected through the semen of the sire, but the rule appears to be that the ovum thus early affected rarely

attains to its full intrauterine development. It may be affected from the tuberculous generative organs of the dam, but here again abortion is liable to cut short the existence of the embryo. In spite of all drawbacks a certain small proportion of the offspring are affected with tuberculosis and come to the full period of gestation. In case of infection from the dam the disease is especially liable to attack the liver in which so much of the placental blood at once circulates. Cases of the kind are recorded by Malvox, Brouwier, Bang, Lungwitz, Bärlund and Rieck, and in the tuberculous herd of a large public institution in New York several instances were noted.

The infrequency of such an occurrence may, however, be inferred from the fact that in 800,000 calves slaughtered only 7 were found tuberculous.

INDESTRUCTIBILITY OF THE BACILLUS TUBERCULOSIS.

The bacillus may be said to be capable of surviving drying, the action of water, and putrefaction. It is destroyed by heat (162° to 212° F), sunlight, or in one month by heavy salting.

CONDITIONS WHICH FAVOR TUBERCULOSIS.

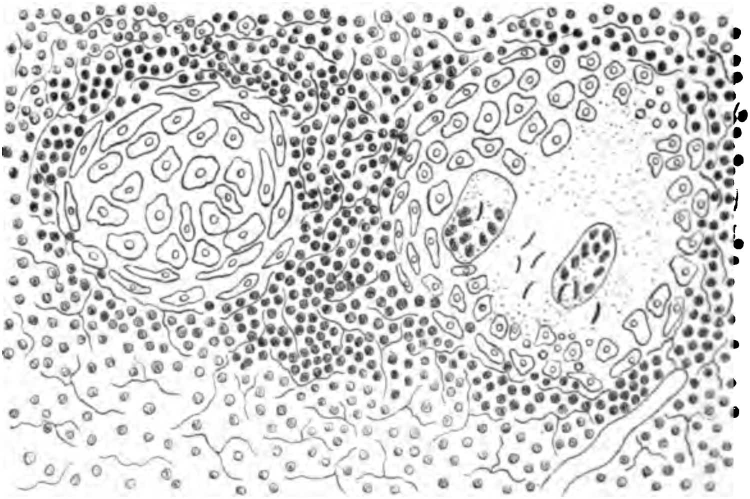
A personal predisposition to tuberculosis is a prime requisite, and this is rendered hereditary by close and inbreeding and breeding in line. Hence the great danger of tuberculosis among improved breeds. Again whatever undermines the health or stamina, such as breeding before maturity, breeding and heavy milking, breeding the old and debilitated, an insufficient ration, an ill-balanced ration which stimulates unduly the secretion of milk, ill health, local inflammations in the air passages, lack of ventilation, constant stabling in dark, damp, undrained stables and wet soils, greatly favor the reception of the bacillus. The impure air, lack of sunshine and accumulation of the germs in large cities make a destructive combination. In France, cities of under 10,000 lose 1.8 per cent yearly from pulmonary tuberculosis, while Paris with its 2,000,000 loses 4.9 per cent. In Vienna hospitals 85 per cent of the bodies show tubercular lesions. In

Bavarian Monasteries 50 per cent of the young postulants die in a few years tuberculous. In New York City charity hospital 30 per cent of all deaths show tubercle lesions. Where country cows are tuberculous to from 1 to 5 per cent, city cows are so from 6 to 20 per cent and upward. On the contrary our prairie and plains fat cattle show but 0.02 per cent tuberculous. In the Southern States with an unbroken outdoor life country cattle are nearly all sound, whereas in large cities like New Orleans they are largely tuberculous.

APPEARANCE AND FORMATION OF TUBERCLE.

The term tubercle is drawn from the rounded nodular form of the diseased process. The bacillus lodged in the tissue multiplies and causes congestion and extraordinary growth of cells. The affected points may be at first no larger than millet seed, but these may increase and run together so as to form conglomerate masses of one, six or nine inches in diameter. As the cell growth increases, the central ones degenerate, die, and form a yellowish

Fig. 2.



2.—*A drawing of a section of a very young tubercle in spleen.* (*Thoma*).

white, soft, cheesy mass (caseation) and these numerous cheesy centres become very characteristic of the disease. Sometimes the tubercle develops into a hard fibrous mass the centre of which may still caseate. In other cases it becomes calcareous or gritty a condition which is usually associated with caseation. Sometimes the caseated mass softens into a whitish cream-like fluid.

COMMON SEATS AND SYMPTOMS OF TUBERCLE IN CATTLE.

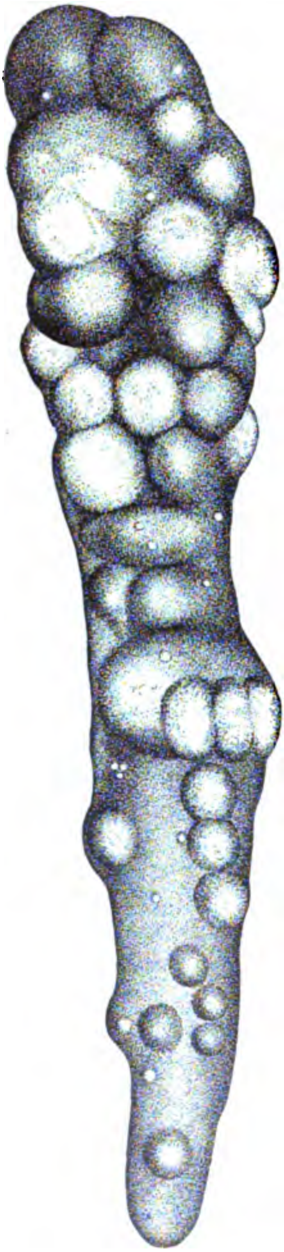
Tuberculosis of the lungs may be chronic or acute. The chronic cases may last indefinitely with no other symptom than an occasional cough on leaving the hot stable for cool air, when suddenly raised in the stall, when made to run, or when drinking cold water or eating dusty food. The cough is usually small, dry, wheezing and repeated several times in succession. The general health may seem to be good, the subject may be fat or a heavy milker. To the trained ear, wheezing, crackling, or other unnatural sounds may be heard in the lungs or they may fail of detection. There may be a discharge from the nose, which when stained and placed under the microscope may show bacilli, but by cleansing the nose with the tongue the animal may make this test practically impossible.

Acute tuberculosis of the lungs on the other hand may prove fatal in a month. It is attended with rapid loss of condition, staring coat, elevated temperature, hurried breathing, frequent weak, husky or rattling cough, heavy, mawkish breath, and nasal discharge containing gritty particles or opaque yellowish masses. Pinching of the back, breastbone or spaces between the ribs, or striking the ribs with the knuckles may cause wincing, groaning or cough, and auscultation over the ribs may detect sounds of friction, wheezing, creaking, crepitation, rattling, or blowing, etc. Percussion over the chest detects areas of lack of resonance corresponding to the seats of tubercles or pulmonary infiltration. A significant feature is that these areas of flatness are distributed over the lungs, and not confined to one spot as is common in pneumonia. Appetite and rumination fail, bloating occurs after meals, the bowels may become irregular, and indications of tuberculosis in the throat, or superficial lymph glands may appear.

Tuberculosis of the stomach and bowels is common in young animals living on milk but is not infrequent in the mature animal as well. It may come from infected milk, or from the swallowing of the diseased products coming from tuberculous throat or lungs. In calves there may be noted indigestion, fœtid diarrhœa, bloating, and finally cough and expectoration or swelling of the superficial lymph glands. In older cattle there may be irregular appetite and rumination, bloating after meals, costiveness alternating with diarrhœa, colics, and marked emaciation. The oiled hand introduced into the rectum may detect the enlarged mesenteric glands, which must be carefully distinguished from hardened fœces in the bowels, from the ovaries, from masses of fat, and from the cotyledons of the womb.

Tuberculosis of the womb and ovaries may depend on infection by the bull, or may be a complication of intestinal and peritoneal tuberculosis. It is usually marked by sterility, abortion, by frequency and intensity of œstrum, and by marked emaciation. Sometimes there is a white vaginal discharge.

Tuberculosis of the liver, spleen and pancreas is also a common accompaniment of infection of the bowel or abdonimal cavity. The liver and spleen are especially liable to suffer from being on the line of circulation of the portal vein which brings blood from all the



3.—Drawing of tuberculous spleen in pig showing tubercles 2-3 the natural size.

other abdominal digestive organs. The lymph glands on the posterior aspect of the liver are especially liable to suffer. With liver-tuberculosis there may be jaundice accompanied by other symptoms of digestive trouble, but as in the affection of the spleen and pancreas there is oftentimes only an indefinite ill health.

Tuberculosis of the kidneys may be attended by extra tenderness of the loins to pinching and by frequent passage of urine, which may be discolored by blood or pus. The urine is likely to contain microscopic cylindroid casts and when stained these may show tubercle bacilli.

Tuberculosis of the udder is usually manifested by a circumscribed or general swelling of one or more quarters, without at first special tenderness, and this gradually extends to the whole gland. The milk may be watery, grumous, or even bloody and the lymph glands in front of the udder and behind are enlarged and hardened. The tuberculous nature of the lesions can only be certainly determined by the discovery of the tubercle bacillus in the milk, by the successful inoculation of the milk on a small animal, or by the tuberculin test.

Tuberculosis of the throat and pharyngeal lymph glands is one of the most common forms of tuberculosis in cattle. It causes a wheezing breathing, glairy discharge from the nose or mouth, difficulty in swallowing and a loose gurgling cough. The diseased glands may be felt as soft swellings around the throat, or as shrunken hard nodular bodies, or as masses fluctuating by reason of their liquid contents. When the disease extends to the interior of the larynx it causes a persistent, paroxysmal, husky cough.

The lymph glands inside the lower jaw or those near the root of the ear may swell up, soften and discharge a cheesy or thick creamy fluid containing the bacillus.

The lymph glands inside the chest—bronchial mediastinal, etc.,—are especially liable to suffer, as they receive the infected lymph which comes from the diseased lungs. These often suffer when no lung disease can be found, the bacilli having passed through the lung without forming any primary lesion in that organ, or those that have been formed having healed. These are often attended by no distinctive symptoms, and require the tuberculin test.

Lymph glands in front of the middle of the shoulder blade may be suspected if of unequal size and form on the two sides, if hard and nodular, or if soft and fluctuating. They rarely caseate and burst.

Other lymph glands that may be similarly affected, and that are superficial enough to be felt, are the *glands at the entrance of the chest* in front of the two first ribs, the *glands on the flank* above and in front of the stifle, and, in the young, the *glands situated high up in the groin.*

Tuberculosis of the bones and joints is seen in young growing animals, affecting especially the large joints of the limbs, the elbow and knee, the stifle and hock, but also at times the bones and joints of the digits. The ends of the bones become enlarged and tender and the joints overdistended, tense and elastic. The lameness may be extreme.

PROPORTION OF OCCULT CASES.

In herds which have the disease in the most intense form, by reason of long standing, indoor life, and repeated reinfection. nearly all may be detected by the objective symtoms, but in such herds nearly every animal is diseased. In ordinary herds, where the disease is less intense, at least two-thirds of the diseased animals would escape under such an examination. In one herd of 70 head in which the tuberculin test condemned 24 head (being 50 per cent of the mature animals) I left the examination after slaughter to the veterinarian of the A. J. C. C. who was at the time skeptical as to the value of the tuberculin test. He wrote me afterward of his surprise at finding every one of the 24 condemned animals tuberculous, when not one of them had shown symptoms by which he could recognize the disease in life. This is no exceptional case, and may be advanced rather as a typical example of the ordinary infected country herd.

It is manifest that if we aim at speedily and certainly clearing a herd of tuberculosis we must have some better method of diagnosing the disease than the best physical examination. Attempts have been made to discover the bacillus in the expectoration, milk or nodular lymph glands, but this requires prolonged care-

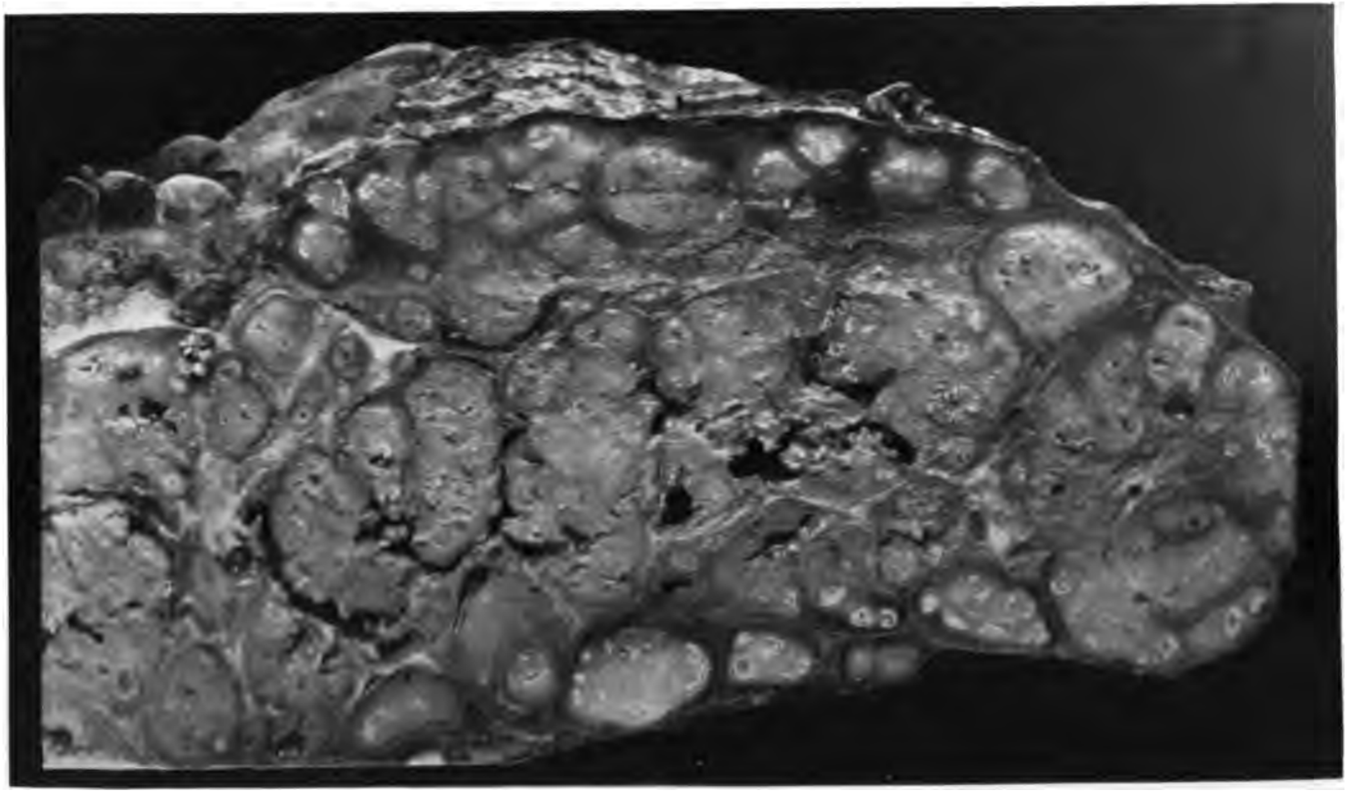


PLATE I.—*Photograph of a section from anterior lobe of a tuberculous lung of a cow, showing rounded tubercular infiltration and calcified centres.*

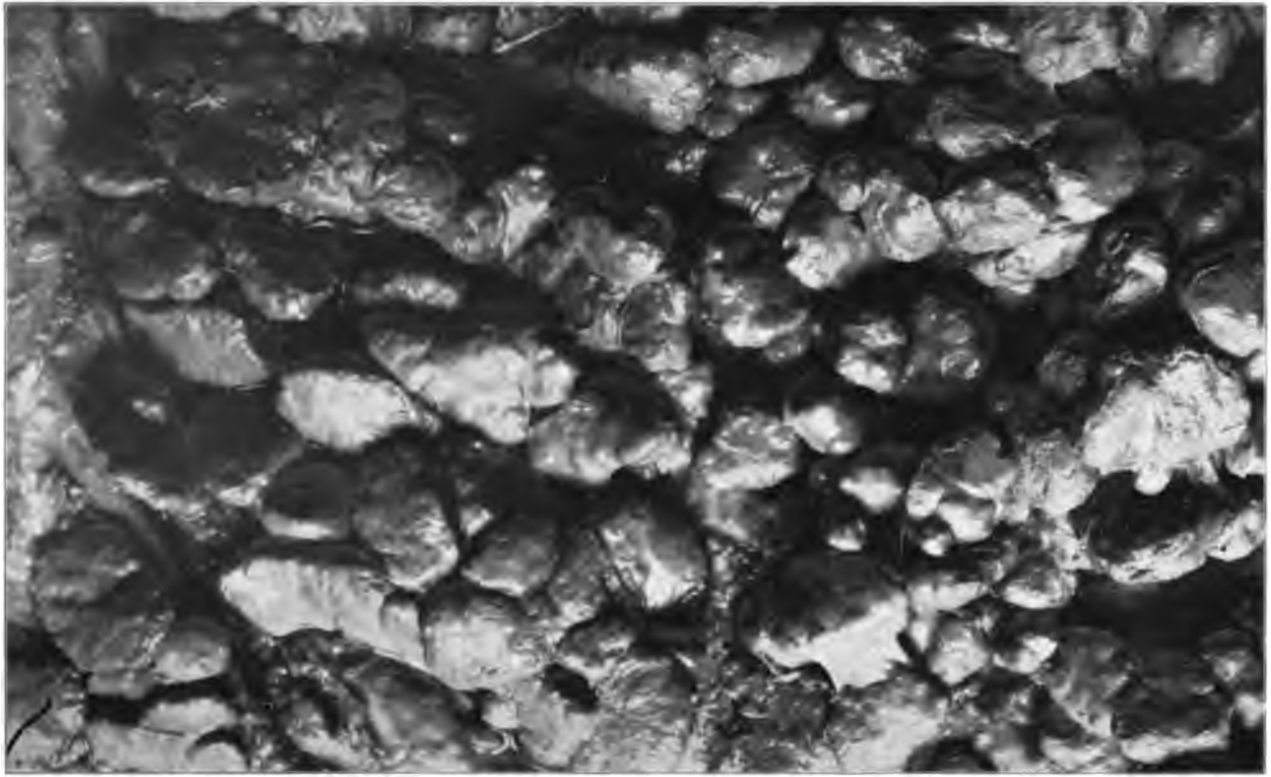


PLATE II.—*Photograph of a portion of tubercular omentum of a cow, showing the tubercles, natural size.*

ful manipulation in almost every case, and, in case of no bacillus being found, is no guarantee of the absence of the disease.

Inoculations with the suspected discharges, secretions or tissues, demand a delay of one or two months before one can pronounce upon the result, and that result if negative, gives no assurance that the animal is free from tuberculosis but only that the material inoculated did not contain the germ.

THE TUBERCULIN TEST.

Much has been said and written against the tuberculin test by those who have never used it, and who are therefore utterly incompetent either to endorse or condemn it, but for those who aim at the prompt and thorough eradication of the infection from a herd, and at the securing at once of a guarantee of progeny, beef and dairy products, no resort can, as regards its efficacy, be at all compared with the tuberculin test.

Tuberculin is a sterile solution of the products of the artificial culture of the tubercle bacillus. In its preparation it has been treated to a boiling temperature which is as fatal to a tubercle bacillus in liquid medium as it is to a hen's egg. But this is not all, even the dead bacilli have been separated from the liquid by passing it through a porcelain filter. The remaining liquid (tuberculin) is absolutely sterile and can plant and propagate neither the tubercle bacillus nor any other living thing. It can poison if given in excessive doses, as alcohol can poison, but it can no more produce the germ of tubercle where that does not exist than can distilled alcohol plant the yeast germ and start a new vinous fermentation. The insane fear of tuberculin is the fruit of an ignorance of its true nature and of a blind prejudice which withholds its victim from informing himself on the subject.

As we produce tuberculin in the bacteriological laboratory of the N. Y. S. Veterinary College, and distribute it free, for use by approved parties in this state, we can speak with confidence of the absolute harmlessness of the agent when intelligently employed. We aim at securing no profit in making this agent, but charge only for packing and shipping. We have therefore no interest in its manufacture, for on the contrary the greater demand from residents of this state for tuberculin the more unremunerated labor is heaped upon us.

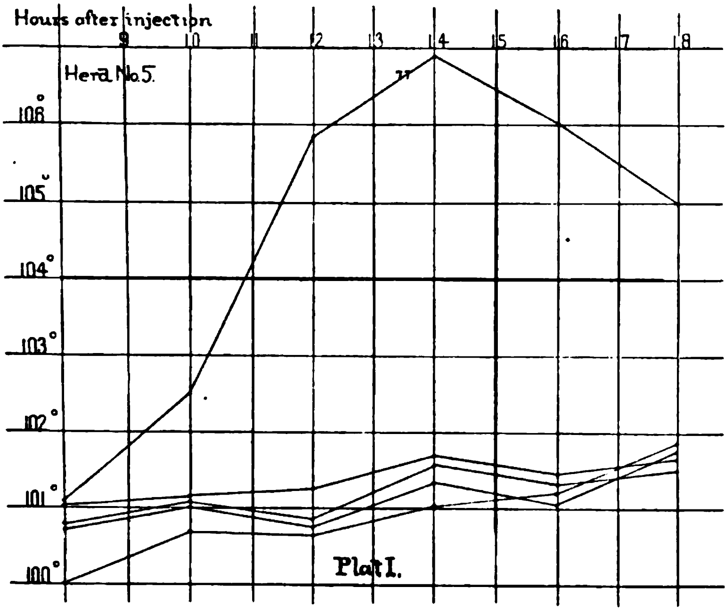
The value of the agent consists in this, that the hypodermic injection of an appropriate dose in a tuberculous animal, however lightly affected, produces in the course of the succeeding twenty-four hours a rise of body temperature and other indications of fever. The gradual rise and fall of the temperature in the absence of any other diseased or physiological condition which would bring this about is the most reliable of all symptoms of the presence of the disease. Upon the sound animal system such a dose of tuberculin produces no appreciable effect.

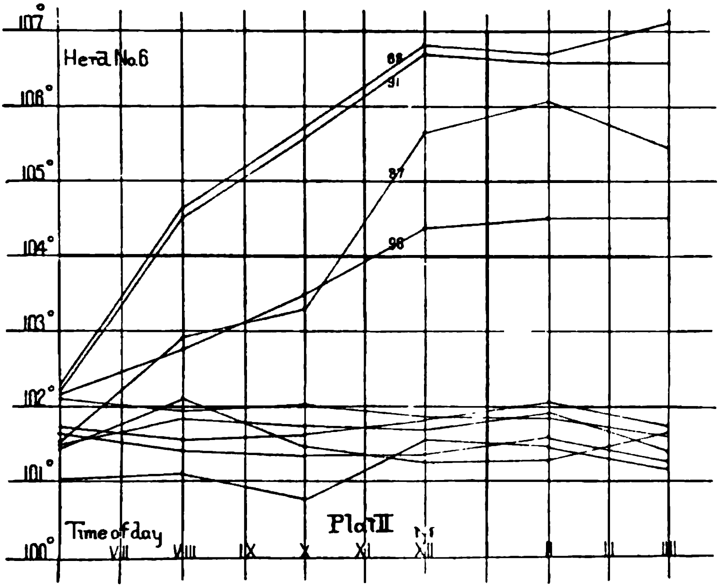
It is important, however, that I should not be misunderstood in this matter. The man who will use tuberculin without due caution and without due consideration as to the condition and environment of the animal, and who blindly condemns on any rise of temperature will almost certainly condemn non-tuberculous animals and bring the tuberculin test into discredit. The intelligent use of the test, demands an intimate knowledge of the kind of animals tested, both in the healthy and diseased condition, and a careful scrutiny before and during the test.

1st. *The subject must be in good general health.* If there is present in the system any concurrent disease it may undergo an aggravation within twenty-four hours and give a rise of temperature that will be mistakenly set down for tuberculosis. At the very start, therefore, it is important that the general health of the subject should be first assured by a critical professional examination. If some other disease is present the tuberculin test had best, as a rule, be delayed until that has subsided, while if tuberculosis is found the test will be superfluous.

2d. *The subject must not be within three weeks of parturition, nor about to abort.* In many cases, though not in all, as preparations are made for calving, the system becomes unduly susceptible to the presence of tuberculin and that agent will cause a rise of temperature, though no tuberculosis is present. Unless this source of error is carefully guarded against the most valuable cows in the herd may be condemned unjustly.

3d. *The cow must not be within three days of the period at which "heat" would naturally occur.* Under the excitement of œstrum





TEMPERATURE CHARTS

4.—*Temperature curves of 5 cows, all of one herd, under the tuberculin test. No. 77 was tuberculous, the other healthy.*

5.—*Temperature curves of 10 cows, all of one herd, under the tuberculin test. Nos. 68, 87, 91 and 98 were tuberculous, the others healthy. (Curtice, Report of the Bureau of Animal Industry 1893-6.)*

the body temperature usually rises two or three degrees, and if tuberculin has been used this rise may be attributed to tuberculosis and a sound animal may be condemned. Nor is it always enough that the animal is supposed to be pregnant. Abortions sometimes takes place unexpectedly and unknown to the owner. If, therefore, a cow under the test and which is not well advanced in pregnancy should show a rise of temperature it should be at once ascertained whether the animal is not in "heat." If symptoms of "heat" are found she should be set aside along with any calving cows to be tested again when such a source of error is no longer present.

4th. *The tested animal must not be exposed to a hot sun in a closed area.* In excess this will cause heat apoplexy, and the fever heat which ushers this in may easily be mistaken for the indications of tuberculosis.

5th. *Cattle taken from pastures must not be enclosed in a hot, stuffy stable.* While they must be tied up to allow of the temperatures being taken at short intervals, coolness and ventilation should be secured in summer by a sufficient air space and the requisite ventilating openings.

6th. *Exposure to cold draughts between open doors and windows, or to wet or chilly blasts out of doors should be carefully guarded against.* A chill proceeding from any source and alike in the presence or absence of tuberculin causes a rise of the internal body temperature.

7th. *Heavy cows unaccustomed to stand on hard boards may have a rise in temperature in connection with resulting tenderness of the feet.* One must avoid hard floors on the day of the test or make examination of the feet and allow for attendant fever.

8th. *Omission of the previous milking or a change of milker and consequent retention of part of the milk* will raise the temperature of a nervous cow, and in careless hands secure an erroneous condemnation.

9th. *Privation of water at the regular time will often cause rise of temperature* especially when on the dry feeding of winter. I have seen a general rise of two degrees and upward from the delay of watering for a single hour, while after watering the temperature went down to the normal and remained so. Water always tends to a temporary lowering of temperature but in the presence of tuberculosis it soon rises again.

10th. *Change of food is liable to produce a slight indigestion and rise of temperature.* This should be avoided as far as possible, and when a herd is taken up from pasture for the test it should have grass, ensilage or other succulent food.

These are examples of the sources of fallacy which attend on the reckless and unintelligent use of tuberculin. They only show that skill and training are necessary to its successful use, and that in the absence of these the apparent results are not to be too unhesitatingly accepted. In all cases, in the absence of the requisite education and experience it is desirable that the animals which have shown a rise of temperature should be separated from the herd and tested anew after the lapse of three or four weeks. In this way such errors may be almost entirely excluded.

11th. *An animal with advanced tuberculosis sometimes fails to react.* The subject is, however, usually emaciated and bloodless, breathes hard and has rapid pulse on exertion and shows unequivocal symptoms of tuberculosis to the skilled examiner. Such cases can, therefore, rarely escape a physical examination. They are noticed mainly to guard against the mistake of making the rise of temperature or its absence the sole test of tuberculosis.

12th. It is objected to tuberculin that it detects even the slightest and most latent cases of tuberculosis, some of which would recover and many would remain useful for years. This objection would be valid if our object were to obtain the greatest possible money return from the individual tuberculous cow at the expense of any risk to the sound herd. But tuberculin is, and should be used for the purpose of a complete eradication of the tubercle bacillus from the herd and the preservation of a sound stock which with its products will be above suspicion. If this is not aimed at; if the latent cases are to be retained in the herd and the advanced cases only removed then truly tuberculin should have no place in your system. Physical examination should be all sufficient for your purpose. But you could not place the herd at once above suspicion, you could not sell its members with a guarantee of soundness, and you could not assure the consumers that the uncooked dairy products were safe.

The animal with local tubercle may not at the present time be diffusing the poison, but where such animals are preserved one will at intervals have the local tubercle extended so as to cause generalized tuberculosis; and as this extension necessarily takes place by the conveyance of the bacillus through the blood, and as such bacilli must be circulating in the blood before they can invade new tissues and form new tubercles, it follows that there is always a period between the entrance of such bacilli into the blood and the development of new tubercles in which the blood and all blood-containing organs are infecting, though no symptom nor lesion of new tubercles can be detected. At this stage the animal may convey tuberculosis through its flesh, or through its dairy products, while even a post mortem examination would pronounce it free from generalized tuberculosis. It is also liable to distribute the germ to other members of the herd before any suspicion of immediate danger is entertained.

Deduction. It may be concluded from such considerations as the above that the tuberculin test is indispensible where one aims at a guarantee of the soundness of the progeny and dairy products of a herd, but that its use demands one of two conditions.

A. That the animals showing tuberculosis under the test shall be destroyed and the buildings where they have been shall be disinfected ; or,

B. That such infected animals, as have the disease in a latent form, shall be formed into a separate herd and kept well apart from other stock, for breeding purposes only ; or if their milk is used that it shall be first subjected to sterilization.

The stockowner who values the sound portion of his herd cannot afford to allow even the latent cases of tuberculosis to mingle with it.

TUBERCULIN IN MODERATE DOSE HARMLESS TO SOUND CATTLE.

The concurrent testimony of all veterinarians drawn from hundreds of thousands of tests is that the ordinary test dose is harmless to a nontuberculous animal. In 1894 I put this to a crucial test on five cows (Holstein, Jersey and grade) injecting the tuberculin on six successive occasions and found that it produced no appreciable change in the general health as evidenced by temperature, breathing, pulse, yield of milk or quality of milk. I feel accordingly that I can speak with the greatest confidence as to the entire harmlessness of the tuberculin test on a sound animal.

That it rouses into a temporary activity the tuberculosis already existing in the unsound animal is true. Were it not so it would be useless as a diagnostic agent. But if the state stands ready to destroy and pay for the diseased, there can be no possible objection to the temporary aggravation which leads to the purification of the herd.

MEASURES FOR THE ERADICATION OF TUBERCULOSIS.

For the complete eradication of tuberculosis from a herd or country the first and main consideration is the absolute separation of the sick animal and all its products from the healthy. This is fundamental in dealing with all infectious diseases, and if it could be applied would reduce all contagious disorders to the condition of simple sporadic ones. Plagues would cease to be plagues, and the infecting disease would cease like any other affection with the first individual case. The plagues of men follow the great movements of men—pilgrimages, armies, trade. The animal plagues prevail continuously in unfenced territories (Asia, Central Europe, Australia, Tasmania, New Zealand, South Africa), and follow the tract of armies and the channels of commerce. Stop the great accummulations and intermingling of animals and we arrest the general diffusion of a plague and reduce it to the comparatively insignificant importance of some common disease.

Exceptional cases like anthrax and blackquarter in which the germ is maintained for years in the soil, are only apparent exceptions to this fundamental principle, as whenever the germ can thus be carried in soil or water the separation of sick and their products from the healthy is incomplete.

In applying this principle to tuberculosis we meet with the drawback that a great variety of animals of different genera are susceptible (including the human being) and that it is difficult to keep all these and their products apart, and that further it is not in our power to cut short the disease abruptly in the human race as it is in the lower animals. There is however the counterbalancing advantage that its propagation is slow and takes place less readily through the air than in the case of most infectious diseases.

BREEDING HEALTHY STOCK FROM PARENTS WITH LATENT TUBERCULOSIS.

Where the state is not pledged to exterminate the disease by prompt and radical measures it is quite possible to raise healthy stock from sires and dams that have tuberculosis in a slight and latent form. It will be recalled that calves are usually born free from tuberculosis. In the slaughterhouses of Europe there may be but one tuberculous calf in 100,000 killed. If therefore the calves can be preserved from infection of a parental source they may be raised absolutely sound with very few exceptions. For valuable pedigreed animals especially it is quite possible for the owner to keep those with latent tuberculosis in secluded herds, to remove the calf from its dam as soon as born, and to raise it on the sterilized milk of the dam or on the milk of another and healthy cow.

In such a case it is always desirable to employ the tuberculin test upon the entire herd, to destroy at once those animals that have advanced or generalized tuberculosis, and to separate in a new or disinfected barn under special attendants the cows that have been attested sound. There will remain the slight and latent cases which have reacted under the tuberculin, but which are well nourished, having healthy skins, eyes and appetite, and no cough, wheezing nor shortness of breath. These must be kept well apart in separate barn and pasture where neither they nor their products can come in contact with healthy stock, where they can have good air and nourishing food. Their calves must be kept in a separate building or park, and fed on the milk of sound cows, or on that of their dams after it has been raised to the boiling point for 15 minutes. After sterilization the milk must be put in scalded vessels reserved for the use of the calves, and fed by the special attendants. Any loss of condition, unthriftiness, cough or scouring on the part of a calf, should be the warrant for separating it from the others and subjecting it to the tuberculin test, and for its destruction in case it shows the tuberculin reaction.

The cows should also be carefully watched and in case any one develops cough, wheezing, breathlessness on exertion, or other sign of actively advancing tuberculosis it should be at once destroyed as endangering the others by possible reinfection. The whole isolated tuberculous herd should be submitted to the tuberculin test, every three or six months, and individuals which fail to react on two successive tests, and which show all other indications of good health may be held to have recovered and may be restored to the healthy herd.

A *second* method is that pursued successfully in the North West Territories. Cows and heifers that have reacted under tuberculin, but which otherwise appear to be in good health, are made into a herd by themselves and placed on a special range apart from all other cattle. They live in the open air with slight shelter in winter and their calves are allowed to suck their dams running with them until winter. The wide range, the open air life, and the early destruction, by sunshine and oxygen, of the discharged microbes, tend in the main to ward off infection except such as comes in the milk, and as a matter of fact the majority of the calves grow up in apparent good health and are fattened and shipped to England.

The climate of our Southern States affords a better opportunity for this practice than does the semi-arctic northwest. There the ranch cattle living in the open air all the year round show little or no tuberculosis, and with this outdoor life the genial climate will greatly favor the survival if not the recovery of the slight and latent cases. It should be added that in the stabled cows of the southern cities tuberculosis is very prevalent.

EXTINCTION OF TUBERCULOSIS WITHOUT THE TUBERCULIN TEST.

As successful examples of this I may quote from my own personal experience.

1st. A herd of about 200 head belonging to the Willard Asylum had become badly affected with tuberculosis and on physical examination, without the use of tuberculin, I condemned about 50 per cent. These were accordingly destroyed and new barns and yards were constructed at some distance from the others and filled with cows selected from the most healthy herds available. These were bred to healthy bulls and a new herd gradually built up. Meanwhile the remaining 50 per cent of the original herd were gradually slaughtered, and like the original half of the herd were found to be tuberculous without a single exception. The original barn was thoroughly cleaned, repeatedly disinfected with chloride of zinc and with its cleansed and disinfected yards was left unoccupied for an entire year. The fields on which the original herd had pastured were used for other purposes than pasture for two full .years. The new herd was carefully watched and any cow which contracted a cough or showed especially poor health was at once separated from the herd and disposed of. This treatment of the new herd was kept up for over twelve years, and in the middle of December, 1897, I subjected the mature animals of the herd to the tuberculin test, and found not a single case of tuberculosis. I have never before subjected an untested herd of this size to the action of tuberculin without finding a considerable percentage of cases of tuberculosis. The splendid showing is highly instructive as to the high value of intelligent management even without the aid of tuberculin. Here a large herd was maintained under the same conditions of food, milking and housing (even in the same barns) as the former herd which became universally tuberculous, and, even under the crucial test of the tuberculin, furnished not a single case of tuberculosis. The only difference is that with the present herd intelligent measures were taken to exclude the germ of the tuberculosis. The case is all the more striking that some of the most important precautions against the spread of tuberculosis in a herd were not put in force. The cows were not taught to keep the same stall on all occasions, but went into any stall that was convenient. Then there were no partitions between the feeding places of adjacent stalls and one cow could lick up the food from the two stalls on the right and left as well as from her own. With an infecting cow in the herd, therefore, there was every opportunity for a speedy spread of the infection. In spite of such obvious opportunity for infection the careful selection of the first members of the present herd, the building up of the herd by home breeding only, and the weeding out of all suspicious animals succeeded in excluding any trace of tuberculosis.

The experiment, however, entailed the entire destruction of the original infected herd, and though the post mortem examination showed that in this instance this step was necessary to a successful result yet in many other less universally diseased herds the larger part could have been saved by picking out the diseased with the aid of the tuberculin test.

2d. In Cornell University herd, which numbers about sixty cattle, old and young, tuberculosis led to the destruction of a number of individuals. The diseased, however, were disposed of as soon as objective symptoms showed the presence of tuberculosis, and after some years of this weeding out when I tested the whole herd with the newly discovered tuberculin I could find no trace of the disease except in a young bull which had recently been acquired from another herd. Since his destruction I have tested them repeatedly, but have found no trace of tuberculosis.

EXTINCTION OF TUBERCULOSIS WITH THE AID OF TUBERCULIN.

If a herd has been bred up from home stock without the introduction of any animal from without, and if for a number of years there have been no losses and no illness suggestive of any form of tuberculosis there is a fair presumption that it is free from that disease. But in the average herd, and especially if sickness or death has occurred, even if such has been attributed to something else, it is a wise precaution to subject the whole to the tuberculin test. Especially now when the N. Y. State Veterinary College undertakes to furnish tuberculin free for use in herds in this state, the expense of such a test should not be a serious drawback. The measures to be adopted may be thus enumerated.

1st. Apply the tuberculin test to the entire herd.

2d. Remove all animals showing a rise of temperature which indicates tuberculosis.

3d. Destroy and burn, boil, or deeply bury all cases of the disease, unless it is decided to form an isolated herd of latent cases which are in good condition. (See above.)

4th. In case of doubt or disturbing influences which may have caused rise of temperature (nearness to calving, heat, exposure, concurrent disease, changes in management, etc.), keep the suspected animal apart for three or four weeks and test again. This will almost certainly correct any mistake of the first test.

5th. Repeat the test every three months and if two successive tests show no indication of tuberculosis the herd may be accounted safe.

6th. As soon as tuberculous animals have been removed from a stable let it be vacated and thoroughly disinfected with chloride of lime, 4 ounces to a gallon of water and enough quicklime to make a good whitewash, which will show if even a square inch has been missed. When chloride of lime is objectionable because of its tainting the milk, mercuric chloride may be used in the proportion of one drachm to a gallon of water, to which is added one drachm of sal ammoniac and 5 drachms of common salt. This is much more poisonous than the chloride of lime and must be cautiously handled during its application. The walls, roof, and especially the floor, gutter and feeding trough must be first thoroughly scraped, washed and cleaned, all rotten woodwork must be removed, and in case of double boarded walls, the boards must be removed on one side to permit of a thorough application.

7th. In making new purchases avoid any herd in which tuberculosis has appeared, or which has had sickness or deaths in recent years.

8th. Don't purchase from city, suburban nor swill stables.

9th. Don't take a cow which is in ill health or low condition, especially one with cough, nasal discharge, foul breath, hard nodules under the skin, diseased udder, swollen loins or joints or a tendency to scour or bloat.

10th. Test every fresh animal with tuberculin before admitting it to your herd, unless it has been recently tested and has not since been exposed to possible infection.

11th. Don't admit strange cattle to house, field or yard with your own. Keep them apart until tested with tuberculin.

12th. Keep each animal in your herd strictly to its own stall and manger.

13th. Board up the partitions of the stalls in front so that no two cows can feed from the same manger nor lick each other.

14th. Be especially observant of the older cows and on the slightest sign of ill health separate and subject to the tuberculin test.

15th. In case a herd of cattle is found to be tuberculous subject to the tuberculin test all the domestic animals that have mingled with them freely and fed from the same troughs. Remove those that show a reaction.

16th. Exterminate the vermin (rats, mice, sparrows) in a building where tuberculosis has prevailed.

17th. Let no consumptive person attend on cattle or other live stock, nor prepare their food.

EXTINCTION OF TUBERCULOSIS BY STATE ACTION.

It is out of the sphere of the private breeder or dairyman to enter on the question of state sanitary police, yet no one is more deeply interested in the general enforcement of such measures as would banish the existing dangers which attend on the purchase of strange animals and their products. In recent years the rigid supervision of herds in the New England States has driven many infected cattle into New York to spread tuberculosis in previously healthy herds, and to increase it in those that were already affected.

The exclusion of cattle seeking to enter Pennsylvania or the New England States, which were not accompanied by the certificate that they had successfully stood the tuberculin test, has led to the testing of western cattle at Buffalo, Albany and elsewhere, and the detention of such as failed under the test, to be sold too often to the unsuspecting New York stockowner. The tests have often been made by the inspectors of the Bureau of Animal Industry, who have no legal right to interfere with the condemmed cattle unless the attempt is made to move them into another state, and in the absence of any restriction by the municipal or state health officers, the owner or dealer is at liberty to sell such tuberculous cattle in open market.

If the test is made by a veterinarian who is not a national nor state official the same holds true ; he has no authority to forbid the sale of the diseased and condemned cattle.

Again, private stockowners have had their own herds tested, and have removed from the herd those that failed to stand the test, but there is nothing to show what became of such condemned animals, and in the absence of a state indemnity and slaughter, there is much to be suspected.

These are hints of the evils that have been precipitated for a length of time upon our New York live stock industry. Day by day our herds are being systematically infected by the introduction of the tuberculous offscouring of other states and of our own, and we raised not a finger to stop it.

Further, in the interests of the consuming public we have to consider that we have no inspection in our little local abattoirs and no guarantee of the meats there killed. And meanwhile we are giving free rein to every evil disposed dealer, to add to our herds the tuberculous animals drawn from the states around us.

The crying need of New York to-day is first to block these streams of infection, which are now practically invited into our herds from other commonwealths, and second to inaugurate a systematic effort to rid our own herds, which are the sources of our dairy and meat products from this scourge.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
58 Four-Lined Leaf-Bug, 35 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
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106 Revised Opinion of the Japanese Plums, 30 pp.
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114 Spraying Calendar.
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127 A Second Account of Sweet Peas, 35 pp
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136 Chrysanthemums, 24 pp.
137 Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.
138. Studies and Illustrations of Mushrooms: I.
139. Teird Report upon Jananese Plums.
140. Second Report on Potato Culture.
141. Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142. The Codling-Moth.
143. Sugar Beet Investigations.
144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.
148. The Quince Curculio.
149. Some Spraying Mixtures.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1898.

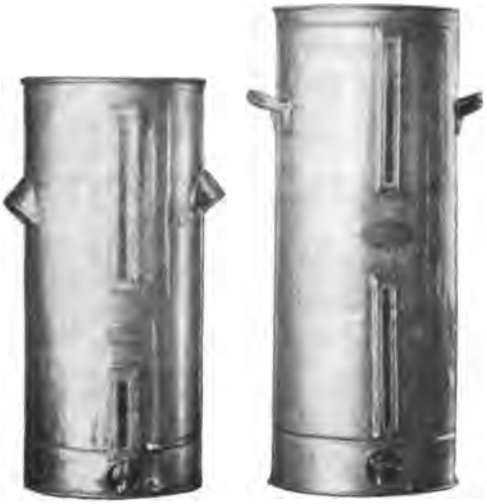
150. Tuberculosis in Cattle and its Control.

Bulletin 151. **August, 1898.**

Cornell University Agricultural Experiment Station,
ITHACA, N. Y.
AGRICULTURAL DIVISION.

Gravity or Dilution Separators.

APPROVED BY THE COMMISSIONER OF AGRICULTURE,
UNDER CHAP. 67, LAWS OF 1898.



By H. H. WING.

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ITHACA, N. Y.
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GRAVITY OR DILUTION SEPARATORS.

Several years ago, before the general introduction of separators, when the deep setting gravity system of raising cream was the method in common use in the larger butter making districts, there occurred in New England and New York a succession of very mild winters when the supply of ice, so necessary in the deep setting systems, was very materially reduced and, in some cases, entirely cut off. To overcome the lack of ice it was suggested that the raising of the cream could be facilitated by diluting the milk with from one half to an equal volume of water, and the claim was freely made that the separation was then as complete as though the milk without dilution had been set in ice water. The whole matter was quite thoroughly investigated by several experiment stations,* and the following general conclusions quoted from the Cornell University Agricultural Experiment Station Bulletin 39 have since been pretty generally received as authoritative:

"Combining the results of this Station with the results at the Vermont Station, we have the following average percentages of fat in the skimmed milk under the different systems:

Diluted,	set at 60°	(39 trials)	.77%
Undiluted,	set at 60°	(30 trials)	1.00
Undiluted,	set at 40°	(26 trials)	.29

"It would seem therefore that while, when the milk is set at sixty degrees or thereabouts, there is considerable advantage, so far as the efficiency of creaming is concerned, in diluting it with 25 per cent of warm water; this dilution cannot be regarded as a substitute for setting without dilution in ice water, and it has the further disadvantage of requiring increased tank capacity and producing a rapidly souring cream."

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*Vermont Agr. Expt. Sta., Newspaper Bulletin No. 3 and 4th Annual Report, pp. 100-107.

Cornell Univ. Agr. Expt. Sta., Bulletins Nos. 20, 29 and 39.

University of Illinois Agr. Expt. Sta., Bulletin No. 12, p. 376 and Bulletin No. 18, p. 30.

It might be added that the diluted skimmed milk is very materially lessened in value for feeding purposes.

Within the past year or year and a half numerous letters have been received making inquiries into the merits of so called "dilution" or "gravity" separators. Since the early spring of this year these inquiries have been much more frequent and it finally seemed worth while to make a somewhat careful trial of the merits of these "separators." So far as is known, the attention of the public has not been called to these "separators" through the agricultural or dairy press by advertisement or otherwise, and they have been introduced almost wholly by retail agents travelling through those sections where only small herds of cows are kept and where the old shallow pan system of creaming is still in use. (Circulars of two of these "separators" finally came into our hands and a representative of the station bought one of the smaller sizes of each kind direct from the manufacturers.) They are known respectively as "Wheeler's Gravity Cream Separator" made by the Gravity Cream Separator Co., Mexico, N. Y., and "Hunt's Improved Ventilated Cream Separator" made by the Hunt Manufacturing Co., Cato, N. Y. Another known as the "Aquatic Cream Separator" made by the Aquatic Cream Separator Co., Watertown, N. Y., has been sent us for trial, and there may be still others on the market.

The somewhat extravagant claims made for these "separators" are best shown by quoting from the circulars and directions sent out with the machines as follows:

"WHEELER'S GRAVITY CREAM SEPARATOR.

"A new device to separate cream from milk by the dilute process, which reduces the viscosity of the milk, thereby securing the cream in two hours. No ice to handle, no cranks to turn, no machinery to run and keep in order.

"It is way ahead of the best creamery, being the *cheapest*, *best* and *easiest* device to handle milk on the market, and you will make no mistake if you investigate its merits.

"VISCOSITY.

"There is a property in milk called viscosity. It is caused by the solids in milk aside from the butter fat. It is a sort of stickiness that retards the raising of the cream. By proper dilution with water we can so reduce this viscosity that the cream will separate or rise in two hours. And, on the same principle, anything that will help the cream up quickly, will also help it to come up thoroughly, therefore we claim we get cream, not only much quicker, but cleaner than with the creamery.

"WE TAKE OUR OWN MEDICINE.

"Have used the *Gravity Cream Separator* in our own dairy the past season to the satisfaction of ourselves and our customers, who pay us an extra price for our butter. Every dairyman that makes butter should use the *Gravity Cream Separator*, and every one that takes their milk to the cheese factory should use it spring, fall and Sundays.

"Those that keep only one or two cows, as well as the large dairyman, can have the advantage of a separator at a small cost, compared with the centrifugal separator or creamery.

"IMPORTANT THINGS TO THINK ABOUT.

"In these times of low prices how can we reduce cost of production?

"First. In handling our milk we can reduce the first cost several hundred per cent over any other device by using the *Gravity Cream Separator.*

Second. It does away with *storing*, *handling* and *cost* of ice.

Third. It saves more than half the work.

Fourth. It is easy to wash and keep clean.

Fifth. It runs itself.

Sixth. It is durable, being well made of heavy tin.

Seventh. It makes ladies happy.

Eighth. It is endorsed by the Grange.

Ninth. Practical dairymen give up their creameries to use the *Gravity Cream Separator.*

"Sizes made to fit any dairy from one cow up. State the number of pounds of milk you have to separate per day and we will quote prices.

"STARTLING FACTS,

"Brought to light from the experience of practical dairymen the past season, have shown that the diluted sweet milk from the

Gravity Cream Separator is superior for feeding purposes to the undiluted sour milk from pan system. And many claim it is better than the milk from the Centrifugal Separator. This may look like a bold assertion, but it is easily explained.

"THE REASON WHY.

"The solids left in the milk after the butter fat is extracted are what give the feeding value to the skimmed milk. The Gravity Cream Separator leaves these solids in the milk, but the Mechanical Separator, by its great speed, collects these solids and deposits them in the bowl of the Separator in the form of ropy, sticky and offensive substance made offensive by the great speed and friction in the bowl of the machine.

"WHEELER'S GRAVITY CREAM SEPARATOR.

"U. S. AND FOREIGN PATENTS PENDING.

"*Directions for Using the Gravity Cream Separator.*

"Place the Separator on a bench or box in any convenient place, with the front projecting over a little, so that a pail can be placed under the faucet without disturbing the Separator when drawing off the milk and cream. Place over the top of the Separator two or three thicknesses of cheese cloth, and fasten with the wire strainer holder. Pour the milk from a strainer pail through the cloth, then dilute with as much good well water as you had of milk. Stir till well mixed. With Jersey, or any rich milk, use more water. In fact, you can't hurt the cream or butter with water, for water and butter fat will not mix, and water absorbs impurities and taints in milk, thereby improving the quality of the butter.

"In very cold weather, if the milk gets cooled off before it is taken to the house, add enough warm water to it to bring it up to 90 degrees, or 100 degrees, before it is put in the Separator; then put in Separator and dilute with cold water as per directions. Remove the strainer cloth and replace with mosquito netting to keep out flies and give plenty of ventilation. Any time after two or three hours, or between milkings, you can draw off the milk and cream. Partly close the faucet when the cream shows in lower gauge. Keep the cream in a cool, sweet place and stir often till you have enough for churning, then warm up to 65 to 70 degrees, and keep 12 to 24 hours to ripen. Churn at 60 to 62 degrees in summer, and 65 to 70 degrees in winter. Davis Swing or Barrel churn best for Separator cream. The churn should be less than half full of cream for quick time in churning.

Be sure and have the cream well ripened. If the Separator is rightly managed you will get all the cream, and if the cream is rightly handled you will get all the butter."

The following is the description and directions for using Hunt's Improved Ventilated Cream Separator:

"TO THE PUBLIC.

"Hunt's Improved Ventilated Cream Separators have been on the market for nearly a year. They are now no experiment, having been subjected to the most critical experiments and have fully demonstrated themselves as the most perfect device for separating cream from milk. We have placed them before Farmers' Institutes in this State, also Michigan, Ohio and Nebraska, and they were endorsed by them as the best and cheapest labor saving device for making butter ever put on the market.

"HUNT'S IMPROVED VENTILATED CREAM SEPARATOR.

"A new device to separate cream from milk by a dilute process, which reduces the viscosity of the milk, thereby securing all the cream in a few hours. It is far ahead of the best creamery, being the cheapest and easiest device to handle milk.

"VISCOSITY.

"There is a property in milk called viscosity. It is caused by the solids in milk aside from the butter fat. By proper diluting with water we can so reduce this viscosity that the cream will separate and raise in one or two hours, and on this principle anything that will help the cream to raise quickly will also help it raise thoroughly. We claim to get the cream not only quicker but cleaner than by any other method when using our Ventilated Cream Separator. Your butter is sweeter, harder and much better than the old method when using pans. Every dairyman should use the Improved Ventilated Cream Separator. It will work as well in winter as in summer, and can be placed in any convenient place near the well or kitchen pantry, etc. Those that keep only one or two cows, as well as large dairymen, can have the advantage of a Separator at a small cost compared with the centrifugal separators or creameries.

"IMPORTANT TO DAIRYMEN.

"In these times of low prices of butter, how can we reduce the cost of production?

1st. In handling our milk we can so reduce the cost one hundred per cent by using Hunt's Improved Ventilated Cream Separator.

2d. It does away with the cost of handling and storing ice.

3d. It saves more than half the labor.

4th. It is easy to keep clean and sweet.

5th. It runs itself; no crank to turn, no machinery to get out of order.

6th. It is ahead of any separator on the market, and made from the best brands of XXX charcoal tin, such as we used to get years ago.

7th. It is the only and original cream separator on the market with inside ventilation, thereby saving one-third more cream.

8th. Practical dairymen give up their creameries to use the Hunt's Improved Ventilated Cream Separator, as it requires *no ice* and gives the same satisfaction.

9th. It is endorsed by Farmers' Institutes, the Grange and all other professional butter makers.

10th. Don't try a separator until you have tried ours. We lead; others try to follow. Be sure that your separator has an inside tube for ventilation. All others are an infringement, and you will have to pay a royalty for using any other.

"*Directions for Using Hunt's Improved Ventilated Cream Separator.*

"PATENT APPLIED FOR.

"Place the separator on a shelf or box, the front of can projecting far enough to place a pail under the faucet without disturbing the can when drawing off the milk and cream. Place over the top of the can two thicknesses of cheese cloth and fasten with the wire strainer holder. Pour the milk from strainer pail through the cloth, then add to the milk the same amount of water at 50 or 60 degrees. Mix both together stirring it for a few moments. Remove the cheese cloth from top and replace a piece of mosquito netting to keep out flies and other insects. After three or four hours setting it will be ready to draw off the cream. Partly close faucet when cream shows in lower gauge. When about one inch of milk remains to be seen in gauge close faucet and then draw balance of milk and cream in a separate dish. Keep the cream in a cool place until there is enough for churning, then warm the cream to 65 or 70 degrees. Twelve to twenty-four hours is necessary to ripen. Churn at 62 degrees in warm weather and 65 degrees in winter. We guarantee one-third to one-half more cream by using this separator than from any other on the market."

The "machines," as shown by the cut on the title page, are simply tin cans fitted with upper and lower scale glasses, a faucet at the bottom through which the skimmed milk is drawn off and a wire ring at the top for holding a strainer cloth or cloth cover. Hunt's has in the middle of the can a narrow tin tube, open at the top and bottom, which constitutes the ventilating feature of the apparatus.

There is absolutely nothing new about these cans. They are entirely similar in all essential features to the cans used in the various deep setting gravity cream raising processes, as the Cooley, Moseley and others. Even the ventilating tube is not a new device. So far as is known neither is patented although "Patent is applied for" in the case of each, and the circulars of Hunt's give strong warnings as to infringement.

Attention is called to the way in which the term separator is used in the name of these cans and in the descriptive matter concerning them. As is well known, there are two forces used to separate cream from milk; the force of gravity acting upon a mass of milk at rest in a suitable vessel, and centrifugal force acting upon milk in motion in a rapidly revolving cylinder or bowl. By common and universal consent the machines separating milk in this latter way are alone known as cream separators, and while it is certainly strictly true that any apparatus in which cream is separated from milk may be called a cream separator, it is as certainly misleading to apply the term cream separator to any other than a centrifugal separator. An old-fashioned shallow pan is just as much and just as truly a "cream separator" as are these cans. It is plainly evident in the above circulars, though it is not distinctly so stated, that the idea is intended to be conveyed that these are separators similar, at least in efficiency, to centrifugal separators.

THE AQUATIC SEPARATOR.

This apparatus (Fig. 6) made by the Aquatic Cream Separator Co., Watertown, N. Y., only differs from the others in the fact that the can is of considerably larger diameter and is provided with another smaller can intended to be filled with ice and inserted in the large can as a cooler. The descriptive circulars and printed directions are strikingly similar to those of Wheeler's and Hunt's and many of the same phrases are employed. In fact, the same company send out a can, intended to be used without the central ice can, that is entirely like Wheeler's except that it is slightly taller. The Aquatic Cream Separator was patented on June 7, 1898, and on consulting the *Official Gazette* of the United States Patent Office, Volume 83, No. 10, June 7, 1898, it was found that on that date a patent was granted as follows:

6.—*The Aquatic Separator.*

"605252. Apparatus for separating cream from milk, Chester L. Lee, Ellisburg and Frederick G. Lee, Pierrepont Manor, N. Y. Filed Sept. 13, 1897. Serial No. 651,446. (No model.)

"*Claim*—An apparatus for separating cream from milk comprising a milk can provided with a centrally depressed bottom and having an outlet in the center of said bottom, a cooler within said can and provided on its bottom with feet supporting the cooler over said outlet with passages under the cooler, said feet serving to prevent eddying of the outflowing liquid and causing a draft of said liquid equally from all sides of the can to the outlet and also promoting the discharge of the sediment from the bottom of the can substantially as described."

It will be seen that the claim for the patent is based upon the outlet of the large can which is "centrally depressed and at the center" and in the construction of the legs or supports on the bottom of the cooler. In the can received by us from the company, the outlet is not in the center but at the side, and the cooler, without any legs or supports whatever, is made to set flat upon the bottom of the larger can. It would seem as though the patent must be regarded, even by the company, as of practically no value.

PRACTICAL TRIALS.

All three of these "Separators" have been used according to the directions. The room in which the cans were set was at a temperature of 65-75 degrees. The water used was at a temperature between 50 and 60, and in all cases the cans set rather more than twelve hours before they were skimmed. They were skimmed by drawing the mixture of skim milk and water from the bottom till the cream line was within one inch of the bottom of the can. The fat in this skim milk and water was determined by the Babcock Test, and then correcting for the water added, the percentage of fat in the skimmed milk and water was secured.

The milk used was, at first the mixed evening's milk of the University herd and it was set as soon as milked and taken to the dairy. Many of the cows were in advanced lactation and giving small amounts of milk, and it was found that it creamed very imperfectly though we had been having no difficulty at all in skimming it perfectly clean with the centrifugal separator. For the later trials the milk of a few cows fresh within two or three months was reserved so that the trials have included milk that is representative of all milk likely to be found on farms.

In all the trials made with Hunt's and Wheeler's cans comparisons were made with Cooley cans set in ice water without dilution. The trials with the Aquatic were made later with milk from the same cows, but no comparisons were made with the Cooley. The results are shown in the tables following:

TABLE I. MIXED HERD MILK. MANY OF THE COWS NEARLY DRY.

			Wheeler's.						Hunt's.						Cooley.			
Date.	Number of hours set.	Per cent fat in whole milk.	Pounds milk.	Temperature.	Pounds water.	Temperature.	Temperature when skimmed.	Per cent fat in skim milk.	Pounds milk.	Temperature.	Pounds water.	Temperature.	Temperature when skimmed.	Per cent fat in skim milk.	Pounds milk.	Temperature.	Temperature when skimmed.	Per cent fat in skim milk.
July 6.....	14	3.95	30	92	30	53	70	.76	25	92	25	53	69	.66	33½	92	42	.90
" 7.....	14½	4.1	25	86	25	56	72	.86							53	86	40	1.25
" 8.....	15	3.6	25	94	25	50	72	1.00							35	94	38	.80
" 9.....	12	3.9	20	88	20	48	66	1.00	25	88	25	48	68	1.00	28	88	42	1.20
" 11.....	17	3.6	20	92	20	56	64	1.20	28	92	28	56	64	1.00	20	92	44	1.00
" 12.....	16	3.6	20	87	20	47	63	.80	28	87	28	47	65	1.40	34	87	38	
																		.90
			Average				....	.94	....					1.01	....			1.01
TABLE II.—MILK FROM COWS COMPARATIVELY FRESH.																		
July 13.....	16½	3.75	20	94	20	56	70	.90	28	94	28	56	70	1.40	33	94	40	.50
" 14.....	16	3.7	20	94	20	55	72	.80	28	94	28	55	72	.80	33	94		.50
" 15.....	16	3.75	20	94	20	54	72	.40	28	94	28	54	72	.40	33	94	40	.60
" 16.....	16½	3.8	20	94	20	60	70	.60	28	94	28	60	71	.40	34	94	37	.50
" 17.....	16	4.	20	95	20	50	73	1.00	28	95	28	50	73	.90	37	95	38	.65
" 18.....	16	3.9	20	96	20	48	75	.90	28	96	28	48	75	1.90	34	96	42	.50
" 19.....	16	3.65							36	96	28	58	76	1.00	38	96	40	.50
" 20.....	16	3.45							30	95	30	54	74	.60	34	95	41	.40
" 21.....	15½	4.1	20	94	20	58	75	.90							35	94	44	.65
			Average				....	.79	....					.93	....			.53
			Average both tables				.....	.86	....					.96	....			.72

TABLE III. MILK FROM COWS COMPARATIVELY FRESH.

Aquatic Cream Separator.								
Date.	No. of hours set.	Per cent fat in whole milk.	Pounds milk.	Temp.	Pounds water.	Temp.	Temp. when skimmed.	Per cent fat in skim milk.
July 27.	15	3.25	50	96	50	52	66	.60
July 29.	15	3.3	45	94	45	44	62	.80
July 31.	15	3.4	37	94	37	50	56	.50
Aug. 1.	15½	3.1	54	93	54	50	61	.70
Aug. 3.	15½	3.8	61	94	61	44	62	.50
							Average.....	.62

We have also taken occasion to test several of these cans in actual use by farmers in this and adjoining counties. In all, five different places were visited and four or five tests made at each place. The cans were all of the same form as Wheeler's, that is, plain cans without ventilators or coolers. The milk was set about twelve hours and was at a temperature, when skimmed, of from 68 to 70 degrees. The whole milk contained from 4 to 5 per cent of fat and was largely the milk of Jersey and Jersey grade cows. Equal parts, by measure, of milk and water were used. The results were as follows :

TABLE IV. TESTS AT FARMS.

Farm No. 1.		Farm No. 2.		Farm No. 3.		Farm No. 4.		Farm No. 5.	
Date.	Per cent fat in skimmed milk.	Date.	Per cent fat in skimmed milk.	Date.	Per cent fat in skimmed milk.	Date.	Per cent fat in skimmed milk.	Date.	Per cent fat in skimmed milk
July 14 a. m.	1.00	July 25 a. m.	1.10	July 25 a. m.	.90	July 25 a. m.	1.00	July 25 a. m.	1.20
" 14 p. m.	.30	" 25 p. m.	1.10	" 25 p. m.	1.00	" 25 p. m.	.90	" 25 p. m.	1.50
" 15 a. m.	.50	" 26 a. m.	.90	" 26 a. m.	.80	" 26 a. m.	.80	" 26 a. m.	1.00
" 15 p. m.	.90	" 26 p. m.	.80	" 26 p. m.	.80	" 26 p. m.	.90	" 26 p. m.	1.10
" 16 a. m.	.60	" 27 p. m.	1.10	" 27 p. m.	1.00	" 27 p. m.	.90		
Average....	.66	Average....	1.00	Average....	.90	Average....	.90	Average....	1.20

Before calling attention to these tables in detail, a few words of explanation as to what is meant by efficient creaming may be of service in helping to a clear understanding of the whole matter. The separation of cream from milk is always attended by the loss of some fat which remains in the skimmed milk. The less this fat is, the more efficient the creaming and *vice versa.* The percentage of fat in the skimmed milk is therefore the most convenient measure of the loss that has occurred in any process of separation.

Centrifugal separators have been so perfected that the loss of fat in the skimmed milk is reduced to a minimum, and for several years it has been recognized by both manufacturers and users of separators that the percentage of fat in the skimmed milk need not be more than .1 of 1 per cent, and in actual practice it is found that there is seldom more than .2 of 1 per cent in the skimmed milk. When a gravity process, either deep or shallow setting, is used the percentage is larger and considerably more variable. When the conditions are all favorable the efficiency, particularly of the cold deep setting, approaches the centrifugal separator, but it is not infrequently in gravity creaming to find one per cent or more of fat in the skimmed mllk.

In the summer of 1892 seventy farms were visited and the fat determined of the skimmed milk at each place. On forty of these farms shallow pans were used and on thirty a deep setting system, in most cases the Cooley, was in operation. The average results were as follows :

	Per cent of fat in skimmed milk.		
	Lowest.	Highest.	Average.
Forty farms using shallow pans	.15	1.63	.39
Thirty farms using deep setting	.14	.60	.30

We are now able to judge of the efficiency of these gravity cans. It will be seen that in no case do they approach anywhere near the efficiency of the centrifugal separator and, in most cases, the percentage of fat in the skimmed milk is decidedly more than would be called good creaming by either the shallow pan or deep setting process. In table I where "stripper" milk is used they show an average efficiency about equal to the Cooley, but where the milk of fresher cows were used (Table II) the Cooley gave distinctly better results. The tests made at the various farms show rather higher percentages of fat in the skimmed milk than were obtained here and give a fair idea of the results likely to be obtained under ordinary farm conditions.

CONCLUSIONS.

Gravity or dilution separators are merely tin cans in which the separation of cream by gravity process is claimed to be aided by dilution with water.

Under ordinary conditions the dilution is of no benefit. It may be of some use when the milk is all from "stripper" cows, or when the temperature of melting ice cannot be secured. (C. U. Agr. Exp. Sta. Bull 39.)

These cans are not "separators" in the universally accepted sense of that term and cannot rank in efficiency with them.

They are even less efficient than the best forms of deep setting systems, such as the Cooley Creamer.

They are no more efficient than the old fashioned shallow pan; but perhaps require rather less labor.

In all probability they would give better results if used without dilution and immersed in as cold water as possible, preferably ice water.

THE FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION TO THOSE WHO MAY DESIRE THEM.

39 Creaming and Aerating Milk, 20 pp,
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
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147. Fourth Report upon Chrysanthemums.
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149. Some Spraying Mixtures.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1898.

150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.

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Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

AGRICULTURAL DIVISION.

STUDIES IN MILK SECRETION

DRAWN FROM

OFFICIALLY AUTHENTICATED TESTS

OF

HOLSTEIN-FRIESIAN COWS.

By **HENRY H. WING** and
LEROY ANDERSON.

PUBLISHED BY THE UNIVERSITY.
ITHACA, N. Y.
1898.

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STUDIES IN MILK SECRETION.

In 1894, in response to inquiries from several Breeder's Associations, the Cornell University Agricultural Experiment Station agreed to send an authorized representative to supervise the milk and butter records of thoroughbred cows for any one desiring such records made, upon conditions laid down by the Station. Thus far there has been but little call for supervisors of such tests, except among members of the Holstein-Friesian Association of America. In fact, there has been but one seven-day test made of cows of any other breed. In 1885, this association adopted a set of rules establishing what is known as a system of Advanced Registry, into which no cow is allowed to be entered until she has made a certain record for milk or butter production, the amount of this record depending upon her age. The wisdom of adopting such a system has been attested by the uniform success attending the carrying out of its provisions, and in 1894, the Association added another and still more valuable feature, consisting of what are called "Officially Authenticated Butter Records." For these records prizes amounting to about $1,300.00 are given annually. "Such records must be for seven consecutive days and must be supervised by an officer of some Experiment Station or State institution, or by the Superintendent of Advanced Registry or some inspector designated by him." The rules also provide "that such records may be made by the churn or by the Babcock test, or by any other method approved by the Association of Official Agricultural Chemists." The Babcock test, however, owing to its simplicity and accuracy has been universally adopted as the means for determining the amount of butter fat produced, from which the equivalent butter is calculated. It has also been the almost universal custom among breeders to look to the Experiment Stations for supervisors of tests. The first year, however, that of 1894, of the twenty-five official records published from tests made in New York State only four were supervised by representatives from this Station. On the other hand, during the succeeding years all but three of the official records published from this State have been supervised by representatives from this Station. The men who have supervised these tests are Professors H. H. Wing and G. C. Watson, and Messrs. J. M. Trueman, S. H.T. Hayes, R. L. Speed, J. M. Johnson, Horace Atwood, Hugh C. Troy, A. R. Ward, H. C. McLallen and Leroy Anderson. It is only from data obtained by our representatives while conducting these official tests that we have to deal in this bulletin.

The method of conducting an official test is briefly as follows: The person supervising sees the cow or cows milked dry before the beginning of the test and is present at each milking thereafter until each test is completed; he weighs the milk of each cow separately, samples the same and makes a determination of the butter fat by the Babcock test. He keeps a careful record of each milking, with its per cent and amount of butter fat, and in his report of the test must make an affidavit to the accuracy and truthfulness of the same. The supervisor also keeps a record of the kinds and amount of food eaten by each animal during the test. The cows are wholly under the control of the owner so far as kind and amount of food, time of milking and general treatment are concerned, but the person making the test has access to the cows at all times in company with the owner or his representative. The owner furnishes a statement of the name and herd book number of the cow, her age and the time at which she dropped her last calf. It is from data obtained in the above manner that the tables contained in the following pages are compiled.

The first tests of Holstein-Friesian cattle conducted by representatives from our Station were begun on May 30th, 1894, and such tests have occurred at various intervals up to the present time. Eight different herds have been visited and 210 separate tests been made of 153 different animals. Some animals have been tested twice and one as many as six times. From these tests and the vast amount of data so accumulated, we believe that something of interest and value can be deduced for the general dairyman as well as for the breeder of Holstein-Friesian cattle.

From such a mass of material it is difficult to glean the more important points and place them in digestible form before the general reader ; but we have attempted to draw out those points that appear of most scientific and practical importance to the student, breeder and dairyman, and to place them in as readable form as possible. With so much data at hand it is natural to make many tables, but we have endeavored to eliminate all such as show figures merely and to present only those which teach some lesson or from which some practical conclusion can be drawn.

All records contained in the following tables were made from tests continuing for seven consecutive days. In these records we have given the amount of pure butter fat produced but not its equivalent in marketable butter. According to the rule adopted by the Holstein-Friesian Association .80 of a pound of fat is considered equivalent to one pound of butter, while the Association of American Agricultural Colleges and Experiment Stations has adopted .85 5/7 of a pound of fat as equivalent to one pound of butter. If one-fourth of the fat be added to itself in the former case or one-sixth in the latter, the fat may be readily and quickly converted to its equivalent amount of butter, e. g., 18 pounds of fat would be equivalent to 22½ pounds of butter according to the former and 21 pounds according to the latter. The average per cent of fat is obtained by dividing the total amount of fat by the total amount of milk produced in the seven days.

In Table I is given the name and herd book number of the the cow, her owner, age at the time of calving, date of beginning the test, number of days from calving to the beginning of the test, pounds of milk for the seven days, average per cent of fat and total pounds of fat for the seven days. The records of the cows are arranged in Tables I and II, (1) according to age, two-year olds coming first, then the three and four year olds, and full aged cows following successively. (All cows five years old or over are considered as of full age.) (2) Under each age, in the order of time in which the cows were tested, beginning with the first test on May 30th, 1894, and continuing in order until the last test on June 25th, 1898. For convenience of reference, each of the records is given a number, which number appears in the column to the left of the cow's name under head of "Number of Test." These numbers begin with the first two-year old test and run consecutively through the various ages of the animals. The two-year olds include numbers 1 to 74, three-year olds 75 to 112, four-year olds 113 to 147 and full aged cows 148 to 210. Thus of the 210 separate tests, 74 are of two-year olds, 38 of three-year olds, 35 of four-year olds, and 63 of full aged cows. According to this system, each cow will have as many different numbers as she has different tests; for example, numbers 37, 88 and 146 all refer to Clothilde Artis Topsy but to tests conducted at different times in her life. All those heifers which calved between the ages of two years ten and one-half months and three years are considered as three-year olds; for it is presumed that at such age they must have had their second calves, and should not, therefore, be classed as two-year olds. In similar manner and for the same reason the heifers that calved between the ages of three years ten and one-half months and four years are considered as four-year olds.

TABLE I.—PRODUCT OF MILK AND FAT.

Number of test.	Name and herd book number of cow.	Owner.	Age at time of calving. Yr. Mo. Da.	Date of beginning test.	Days from calving	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
1	Agnes DeKol's Ellen, 30228	H. Stevens & Sons	2- 0-17	May 30, '94	81	247.125	3.36	8.304
2	Inka Pietertje Mechthilde, 30668	" "	2- 0-27	" "	36	282.250	3.08	8.696
3	Pietertje Kekke, 28352	" "	2- 6- 1	" "	43	295.875	3.00	8.894
4	DeKol 2d's Pauline, 30712	" "	2- 0- 4	" "	63	245.000	3.72	9.116
5	Netherland Dot, 33359	Smith's & Powell Co.	1-11-27	Aug. 28, '94	7	220.688	2.29	5.263
6	Netherland Clothilde Countess, 27965	" "	2- 8-21	" "	32	256.623	3.00	7.688
7	Idene Clothilde, 30277	" "	2- 6-24	" "	28	261.438	2.76	7.217
8	Sadie Vale Concordia, 32259	T. G. Yeomans & Sons	1-11-25	Nov. 20, '94	28	317.625	3.50	11.116
9	America 2d's Pauline Paul, 32260	" "	1-11-26	" "	24	247.000	2.80	6.906
10	America 2d's Pauline Paul. 32260	" "	1-11-26	Dec. 15, '94	49	236.438	2.87	6.780
11	Sadie Vale Concordia, 32259	" "	1-11-25	" "	53	295.250	3.30	9.756
12	Pietertje Hengerveld 2d, 37054	H. Stevens & Sons	1-11- 5	April 1, '95	26	301.000	3.12	9.395
13	Pietertje Witkop's Mechthilde, 34242	" "	2- 7- 0	June 1, '95	34	289.875	2.90	8.447
14	May DeKol, 36233	" "	1- 9- 7	" "	40	281.625	2.95	8.289
15	Lunde Beauty, 34745	Don J. Wood	1-11-17	June 10, '95	42	280.875	3.35	9.473
16	Clothilde Artis Lass, 34743	" "	1-11-28	" "	61	278.875	3.25	9.062
17	Clothilde Artis Bright, 34742	" "	2- 0-11	" "	51	315.500	3.20	10.026
18	Clothilde Artis Belle, 34740	" "	2- 0-29	June 9, '95	61	273.750	3.40	9.372
19	Rag Apple's Clothilde Artis, 34741	" "	2- 1- 1	June 10, '95	58	291.125	3.45	10.024
20	Pauline Paul Grant, 35053	T. G. Yeomans & Sons	2- 1- 4	Dec. 4, '95	68	354.188	2.96	10.487
21	Sadie Pauline Paul, 35054	" "	2- 0-17	" "	48	289.375	3.24	9.386
22	Princess of Wayne 7th's Pauline, 35055	" "	2- 1-11	Feb. 19, '96	22	242.500	3.75	9.082
23	Princess Aaggie's Paul'e DeKol, 35056	" "	2- 0-29	" "	21	243.125	3.24	7.879
24	Aaggie 3's Wayne DeKol, 37098	" "	1-11-13	" "	25	325.500	3.15	10.209
25	Prairie Flower's Pauline Paul 2d, 37168	" "	1-10- 8	April 23, '96	20	321.500	3.17	10.184
26	Mutual Friend's Pauline DeKol, 37171	" "	2- 1-22	" "	51	239.625	3.56	8.538
27	Pauline Paul America 2d, 36909	" "	2-1 -13	" "	57	263.250	3.37	8.860
28	Inka Bess, 40183	H. Stevens & Sons	2- 0-29	May 26, '96	24	298.250	2.82	8.413

Number of test.	Name and herd book number of cow.	Owner.	Age at time of calving Yr. Mo. Da.	Date of beginning test.	Days from calving	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
29	Inka 8th, 37059	H. Stevens & Sons	1–11– 7	May 26, '96	47	242.500	3.15	7.649
30	Inka DeKol, 37062	" " " "	1–11–18	" "	11	306.500	3.24	9.927
31	Pietertje Hengerveld's Lady DeKol, 37060	" " " "	2– 1–11	" "	16	300.375	4.22	12.675
32	Snowball Clothilde, 37527	Don J. Wood	1–11–23	June 1, '96	97	299.313	2.66	7.970
33	Clothilde Jannek Artis, 37526	" " "	1–11–10	" "	74	262.188	3.13	8.219
34	Sweet Bough's Clothilde Artis, 37525	" " "	2– 0–10	" "	78	261.125	2.93	7.656
35	Clothilde Artis Beauty, 37521	" " "	2– 0– 5	" "	84	237.875	3.28	7.814
36	Clothilde Artis June, 37529	" " "	1–10–27	" "	15	243.438	3.24	7.877
37	Clothilde Artis Topsy, 37522	" " "	1–11–24	" "	86	298.250	3.01	8.970
38	America 2d's Pauline DeKol, 37096.	T. G. Yeomans & Sons.	2– 1–29	Dec. 27, '96	21	334.375	2.79	9.339
39	America 2d's Pauline DeKol, 37096*.	" " " " "	2– 1–29	Mar. 21, '97	105	305.188	3.32	10.043
40	Paul DeKol's Mutual Friend, 37172.	" " " " "	2– 0–15	" "	72	242.125	3.50	8.500
41	Paul DeKol 2d's Mutual Friend, 37173	" " " " "	2– 1–23	" "	85	241.188	3.32	8.038
42	Hartog Netherland 2d, 39032	A. F. Cole	2– 2–16	Apr. 18, '97	85	290.625	2.96	8.692
43	Patty Waldorf, 39031	" " "	2– 1–22	Apr. 23, '97	90	244.000	3.12	7.616
44	Aaggie Constance's Netherland 4th, 37256	H. Stevens & Sons	2– 5–10	May 4, '97	23	290.375	3.14	9.111
45	Nether'd Wayne's Pauline Paul, 37095	T. G. Yeomans & Sons.	2– 3–12	May 14, '97	40	315.875	2.69	8.508
46	Clothilde Artis Aaggie Belle, 39862	Don J. Wood	2– 1– 4	May 21, '97	27	269.000	3.46	9.313
47	Clothilde Artis Aaggie Bright, 39864.	" " "	2– 0–23	" "	34	256.313	3.47	8.896
48	Clothilde Artis Aaggie Lass, 39865	" " "	2– 0–21	" "	26	258.188	3.21	8.298
49	Clothilde Artis Constance, 39866	" " "	2– 0– 3	" "	46	275.875	3.05	8.424
50	Clothilde Lunde Artis, 39867	" " "	2– 0– 7	" "	15	281.750	3.34	9.404
51	Hetje 6th's Pietertje, 38945	A. F. Cole	2– 2–10	May 26, '97	6	251.750	3.48	8.783
52	Waldorf Maid, 38938	" " "	2– 0– 3	" "	18	315.750	2.37	7.495
53	Pietertje Tweede, 38949	" " "	1–11–27	" "	35	341.375	2.92	9.980
54	Lily Netherland, 39453	A. W. Brown	2– 0– 7	May 28, '97	112	316.125	2.91	9.185
55	Aaggie Grace Clothilde, 39452	" " "	2– 0– 9	" "	107	280.438	3.17	8.890
56	Mutual Friend 3d's Pauline, 40213	T. G. Yeomans & Sons.	1–11–23	Nov. 30, '97	20	210.625	3.65	7.698
57	Sadie Pauline Paul 2d, 40211	" " " " "	1–11–24	" "	49	156.500	3.39	5.301
58	Plum DeKol, 41677	H. Stevens & Sons	1–11–21	Apr. 2, '98	55	223.500	2.88	6.440
59	Nannette 3ds Pledge 3d, 41407	" " " "	2– 1– 8	Apr. 7, '98	30	312.188	3.76	11.747

60	Aaggie 3d's Wayne's Pauline, 41393.	T. G. Yeomans & Sons	1–11–13	Apr. 18, '98	30	325.625	2.87	9.354
61	Concordia 2d's Pauline, 40212......	" " " " "	2– 3– 3	" "	84	238.250	2.79	6.635
62	Lotty Moselle's PietertjeMechthilde,	A. F. Cole............	2– 2–24	May 20, '98	41	362.500	2.69	9.764
63	Midland Gem, 41611.........[41805	" " "	1–11–19	" "	45	295.563	2.68	7.916
64	Mechthilde of Midland, 41806......	" " "	2– 1–29	" "	46	266.438	2.79	7.456
65	Pietertje Mechthilde of Midland,..	" " "	2– 2– 1	" "	30	282 500	2.74	7.732
66	Hetje 6th's Mechthilde, 41809. [41807	" " "	2– 1– 7	" "	38	292.625	3.07	9.001
67	Shadeland DeKol, 41386...........	W. A. Matteson.......	2– 0–12	May 22, '98	22	315.313	2.86	9.040
68	Inka Hartog 2d, 40507.......	W. H. Dewing........	2– 0–28	" "	21	294.938	2.99	8.830
69	DeKol Lady, 41214......	H. Stevens & Sons....	1–11– 2	May 26, '98	23	312.375	3.00	9.384
70	DeKol Manor Beets, 41216.........	" " "	2– 1–15	" "	31	307.000	3.16	9.695
71	Tehee Clothilde, 41383	A. W. Brown....... .	2– 1–20	June 6, '98	40	283.438	2.86	*8.107
72	Aaggie Pietertje Clothilde, 41384...	" " "	2– 0–17	" "	50	267.188	3.13	8.363
73	Clothilde Grace, 41385............	" " "	2– 3– 6	" "	50	316.188	2.95	9.339
74	Segis Clothilde Pietertje, 44589....	" " "	1–10–25	" "	47	265.875	2.87	7.629
75	Netherland Pietertje Princess, 23963	H. Stevens & Sons....	3– 3–16	May 30, '94	5	297.125	4.24	12.593
76	Mutual Friend 3d, 28389...........	T. G. Yeomans & Sons.	3– 2–24	Nov. 20, '94	17	409.188	4.27	17.472
77	Mutual Friend 3d, 28389...........	" " " "	3– 2–24	Dec. 15. '94	42	355.438	3.59	12.738
78	Inka Pietertje Mechthilde, 30668...	H. Stevens & Sons....	2–11–23	Mar. 31, '95	11	349.125	3.25	11.348
79	Pauline Paul Georgie, 28394........	T. G. Yeomans & Sons.	3– 4–20	May 27, '95	15	344.875	3.30	11.406
80	DeKol 2d's Pauline, 30712..........	H. Stevens & Sons....	3– 1–26	June 1, '95	12	338.250	3.45	11.676
81	Hetty W's Artis Clothilde, 31543 ...	Don J. Wood.........	3– 0– 1	June 9, '95	65	311.500	3.40	10.535
82	Sadie Vale Concordia, 32259........	T. G. Yeomans & Sons.	3– 3–29	Apr. 23, '96	56	414.500	3.50	14.485
83	Aaggie Lily 3ds' Netherland, 34799.	A. W. Brown.	3– 2–24	May 31, '96	50	403.500	3.08	12.411
84	Black Maid Inka, 35162......[35055	A. F. Cole...... ...	2–11–16	June 9, '96	78	338.875	2.60	8.813
85	Princess of Wayne 7th's Pauline,	T. G. Yeomans & Sons.	3– 4– 8	May 13, '97	18	327.000	3.61	11.824
86	Pauline Paul Grant, 35053..........	" " " "	3– 7– 4	" "	47	417.500	2.90	12.116
87	Princess Aaggie's Pauline DeKol,	" " " "	3– 2–22	" "	51	343.000	3.02	10.378
88	Clothilde Artis Topsy, 37522..[35056	Don J. Wood....... .	3– 1– 8	May 21, '97	30	441.250	3.21	14.176
89	Clothilde Artis Raphaella, 37523 ...	" " "	3– 0– 3	" "	58	361.313	2.90	10.462
90	Clothilde Artis Pet, 37524........ .	" " "	3– 0–18	" "	48	312.063	3.08	9.622
91	Aaggie Lily 3d's Pietertje, 37031...	A. W. Brown.........	3– 5– 1	May 28, '97	12	406.188	2.94	11.947
92	Prairie Flower's Pauline Paul 2d, 37168	T. G. Yeomans & Sons.	3– 4–21	Nov. 30, '97	45	310.625	2.85	8.846
93	Mutual Friend's Pauline DeKol, 37171	" " " "	3– 8–12	" "	68	344.125	3.43	11.816
94	Pauline Paul America 2d, 36909....	" " " "	3– 8–24	" "	55	345.500	3.18	11.094

*Economic food test.

Number of test.	Name and herd book number of cow.	Owner.	Age at time of calving. Yr. Mo. Da.	Date of beginning test.	Days from calving	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
95	Nannette 3d's, Pledge 2d, 39518	H. Stevens & Sons	2–10–18	Apr. 2, '98	78	228.625	3.35	7.665
96	Patty's Pet 3d, 38946	A. F. Cole	2–10–16	Apr. 5, '98	31	316.375	2.56	8.091
97	Minnie Hijlaard, 39030	" "	2–10–19	" "	30	318.250	2.84	9.133
98	Patty Waldorf, 39031	" "	3– 3–18	" "	17	364.188	2.97	10.810
99	Zady Bergsma, 37409	H. Stevens & Sons	3– 2– 8	Apr. 7, '98	25	358.438	3.62	12.978
100	Paul De Kol's Mutual Friend, 37172	T. G. Yeomans & Sons	3– 3–29	Apr. 18, '98	27	375.938	3.18	11.955
101	America 2d's Pauline De Kol, 37096	" " "	3– 5–15	" "	27	520.188	3.06	15.903
102	Mutual Friend 2d's Pauline, 41396	" " "	3– 0–13	" "	74	302.813	3.22	9.768
103	Hetje 6th's Pieterje, 38945	A. F. Cole	3– 0–29	May 20, '98	41	384.313	2.89	11.123
104	Clothilde Artis Belle 2d 39861	Don J. Wood	3– 1– 0	May 30, '98	21	349.375	3.12	10.948
105	Clothilde Artis Aaggie Bright, 39864	" "	3– 1–22	" "	14	325.313	3.96	12.875
106	Clothilde Artis Aaggie Lass, 39865	" "	3– 1– 1	" "	25	339.313	3.19	10.824
107	Clothilde Artis Constance, 39866	" "	3– 0–20	" "	38	367.188	3.11	11.423
108	Clothilde Lunde Artis, 39867	" "	2–10–28	" "	64	371.625	3.45	12.821
109	Aaggie Grace Clothilde, 39452	A. W. Brown	3– 3–16	June 6, '98	20	462.375	3.20	14.796
110	Segis Aaggie Grace, 39454	" "	3– 0– 6	" "	27	346.938	3.44	11.811
111	Edith Grace, 39455	" "	2–10–26	" "	38	315.438	2.69	8.512
112	Leah Veeman 4th, 40264	W. A. Matteson	3– 1–24	June 25, '98	23	433.250	2.75	11.908
113	Medora Alice, 22921	H. Stevens & Sons	3–11– 3	May 30, '94	83	299.500	3.27	9.780
114	Pietertje Heugerveld, 24137	" " "	4– 0– 1	" "	62	427.875	3.06	13.124
115	Helena Burke	" " "	4– 3–10	" "	57	418.000	3.21	13.416
116	Inka 4th's Pietertje Rose, 23481	" " "	4– 0–20	" "	36	449.500	2.77	12.449
117	Clothilde 3d's Clothilde, 17955	Smiths & Powell Co.	4– 8–12	Aug. 28, '94	50	231.063	3.03	7.100
118	Netherland Pietertje Hartog, 23962	H. Stevens & Sons	4– 1–14	Mar. 29, '95	12	339.875	3.23	10.972
119	Magadora, 29237	" " "	4– 1– 6	June 1, '95	31	353.625	3.00	10.696
120	Netherland Pietertje Princess, 23963	" " "	4– 2–10	" "	43	434.625	2.95	12.884
121	Mutual Friend 3d, 28389	T. G. Yeomans & Sons	4– 3– 8	Dec. 2, '95	15	427.938	4.27	18.265
122	Segis Aaggie 2d's Pietertje, 32620	A. W. Brown	4– 2– 3	May 31, '96	6	436.875	2.91	12.713
123	Vrouwkje of Hijlaard 8th, 30846	A. F. Cole	3–11–22	June 9, '96	95	403.625	3.14	12.688
124	Rouble 5th's Pietertje, 35079	" "	3–11–29	" "	54	460.000	3.12	14.357
125	Debora's Inka, 30844	" "	4– 5– 0	" "	61	521.250	2.91	15.188

126	Patty's Pietertje Netherland, 30845	A. F. Cole	4- 1-18	June 9, '96	47	418.250	3.09	12.936
127	Inka's Pietertje Netherland Beets	“ “	4 10-14	“ “	104	441.375	2.85	12.568
128	Pauline Paul Georgie, 28394 … [28453	T. G. Yeomans & Sons	4- 4-15	June 13, '96	37	437.625	3.16	13.808
129	Princess of Wayne 7th, 28690	“ “ “	4- 3-20	“ “	40	459.625	2.93	13.450
130	Korndyke Queen, 40580	Albert Webb	4- 1- 9	June 30, '96	29	518.250	3.19	16.558
131	Creamella 2d's Topsy Ann, 35164	A. F. Cole	3-10 28	Apr. 17, '97	30	412.125	2.59	10.671
132	Hartog Pietertje Netherland, 30849	“ “	4-10-13	Apr. 22, '97	62	415.688	3.86	16.258
133	Clothilde Artis Belle, 34740	H. Stevens & Sons	4- 1-10	May 4, '97	14	466.750	3.05	14.272
134	Sadie Vale Concordia, 32259	T. G. Yeomans & Sons	4- 6- 3	May 14, '97	13	494.250	3.66	18.103
135	Hartog Pietertje Netherland, 30849*	A. F. Cole	4-10-13	May 26, '97	96	403.750	3.44	13.819
136	Winana's Pietertje Netherland, 35084	A. W. Brown	3-11-29	May 28, '97	28	420.375	2.89	12.153
137	Catrina 4th's Pietertje Netherland,	“ “	4- 1-23	“ “	18	446.563	3.24	14.457
138	Maplecroft Maid, 35907 … [35085	W. A. Matteson	4- 2-20	Mar. 11, '98	29	398.500	3.01	12.015
139	Netherland Aaggie Madge, 34960	“ “	4- 1-16	Mar. 16, '98	10	355.250	3.02	10.734
140	Belle of Schillaard 3d's Aaggie, 36825	“ “	3-11-19	“ “	10	302.813	3.52	10.648
141	Prisca, 37278	A. F. Cole	3-10-27	Apr. 5, '98	13	316.125	2.73	8.640
142	Princess Aaggie's Pauline De Kol,	T. G. Yeomans & Sons	4- 2-24	Apr. 18, '98	24	478.375	3.02	14.461
143	Maplecroft Gem, 35909 … [35056	W. A. Matteson	4- 6- 5	Apr. 22, '98	12	464.750	3.30	15.357
144	Sijtje Twisk Pietertje, 38233	A. F. Cole	4-10- 0	May 19, '98	19	377.188	3.19	12.041
145	Inka 8th, 37059	H. Stevens & Sons	4- 0- 3	May 26, '98	21	383.500	3.40	13.069
146	Clothilde Artis Topsy, 37522*	Don J. Wood	4- 1-10	May 30, '98	37	415.750	3.29	13.724
147	Segis Inka, 36617	A. W. Brown	4- 6-12	June 6, '98	40	476.625	3.11	14.803
148	Netherland Sadu, 13381	H. Stevens & Sons	5- 8-11	May 30, '94	128	358.875	3.26	11.688
149	Bibiana's Pet, 6778	“ “ “	7- 0-20	“ “	69	385.125	3.15	12.137
150	Aaggie B, 13687	“ “ “	5-10- 2	“ “	74	409.500	2.91	11.918
151	Netherland Hengerveld, 13106	“ “ “	5-10- 3	“ “	65	410.250	3.32	13.627
152	Inka Hartog, 7969	“ “ “	7- 1-16	“ “	3	383.125	2.83	10.960
153	Jessie Beets, 8123	“ “ “	6- 8-20	“ “	65	416.250	3.46	14.433
154	7th Durkje Veeman's Ruby, 13297	“ “ “	6- 1- 2	“ “	68	368.125	3.06	11.257
155	Aegis 10th, 4941,	Smiths & Powell Co.	6- 9-18	Aug. 28, '94	343	228.938	3.83	8.761
156	Clothilde 6th, 1581	“ “ “	8-11- 9	“ “	33	320.625	3.26	10.450
157	Idene Rooker, 9995, H. H. B.	“ “ “	10- 5-10	“ “	15	394.625	2.56	10.003
158	Executrix Netherland, 4942	“ “ “	7- 7-10	“ “	46	319.688	3.06	9.785
159	Netherland Wayne, 13752	T. G. Yeomans & Sons	5-10-16	Nov. 20, '94	59	436.000	2.93	12.767
160	Mutual Friend 2d, 10513	“ “ “	7- 0-17	Dec. 15, '94	22	585.125	3.52	20.608

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* Economic food test.

Number of test.	Name and herd book number of cow.	Owner.	Age at time of calving. Yr. Mo. Da.	Date of beginning test.	Days from calving	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
161	Plum 4th, 17274	H. Stevens & Sons	6- 0- 5	Mar. 31, '95	20	419.000	3.70	15.519
162	Helena Burke, 22916	" "	5- 3- 0	Apr. 1, '95	9	518.250	2.91	15.089
163	Aaggie 3d's Wayne, 10516	T. G. Yeomans & Sons	7- 4- 5	May 27 '95	21	487.063	3.22	15.705
164	Inka Hartog, 7969	H. Stevens & Sons	8- 0-16	June 1, '95	35	494.125	2.95	14.573
165	Plum 4th, 17274	" "	6- 0- 5	" "	82	465.250	3.20	14.837
166	Netherland Wayne, 13752	T. G. Yeomans & Sons	6-11- 4	Dec. 2, '95	53	446.438	2.79	12.470
167	Concordia 2d, 10511	" "	8- 0- 4	" "	42	469.938	3.23	15.190
168	Mutual Friend 2d's Wayne, 18456	" "	5-10- 9	Dec. 3, '95	58	524.563	3.41	17.888
169	Concordia 2d's America, 22979	" "	5- 8-18	" "	60	392.563	2.95	11.568
170	Star's Netherland, 13802	" "	7-10-19	Feb. 19, '96	9	468.188	3.56	16.675
171	Aaggie 3d's Wayne, 10516	" "	8- 3- 5	Apr. 23, '96	17	497.063	3.34	16.582
172	Netherland VanFriesland Beets, 23672	H. Stevens & Sons	5- 5-26	May 26, '96	140	422.375	3.29	13.880
173	Magadora, 29237	" "	5- 1-20	" "	11	444.500	2.84	12.605
174	Netherland Hengerveld, 13106	" "	7-11- 7	" "	23	544.875	3.92	21.333
175	Minnie Maria, 8229	A. W. Brown	8- 7-29	May 31, '96	14	467.563	2.52	11.767
176	Segis Aaggie 2d, 24052	" "	6- 2-12	" "	9	449.125	2.83	12.715
177	Aaggie Grace 2d's Pietertje, 26731	" "	5- 2 -0	" "	61	624.938	2.87	17.906
178	Sweet Bough, 7328	Don J. Wood	9- 2-13	June 1, '96	23	428.875	3.12	13.398
179	Patty's Pet, 5405	A. F. Cole	9-11-13	June 9, '96	89	380.125	3.30	12.562
180	Maid of Eaton Inka, 28448	" "	5- 1-10	" "	54	458.250	2.66	11.371
181	Sadie Vale 2d, 18449	T. G. Yeomans & Sons	7- 2-25	Dec. 27, '96	74	322.813	3.13	10.099
182	Mutual Friend 2d, 10513	" "	9- 1- 3	" "	18	589.250	3.44	20.242
183	Aaggie 3d's Wayne, 10516*	" "	9 2-12	Mar. 21, '97	8	410.000	3.64	14.773
184	Mutual Friend 3d, 28389	" "	5- 6 15	" "	25	431.938	3.83	16.327
185	Patty's Pet, 5405	A. F. Cole	11- 0- 2	Apr. 22, '97	22	453.500	3.57	16.203
186	Janie Hijlaard's Inka, 30852	" "	5- 0-26	Apr. 23, '97	30	446.063	3.43	15.320
187	Helena Burke, 22916	H. Stevens & Sons	7- 3-10	May 4, '97	31	654.125	3.11	20.364
188	Pauline Paul Georgie, 28394	T. G. Yeomans & Sons	5- 3 20	May 12, '97	30	376.125	3.40	12.819
189	Princess of Wayne 7th, 28690	" "	5- 2-29	May 13, '97	30	463.625	3.16	14.680
190	Mutual Friend 3d, 28389*	" "	5- 6-15	May 14, '97	79	363.875	3.34	12.184

*Economic food test.

191	Aaggie Grace's Boy's Topsy, 22946	Don J. Wood	7- 0-17	May 21, '97	39	448.375	2.99	13.410
192	Patty's Pet, 5405*	A. F. Cole	11- 0- 2	May 26, '97	56	460.875	3.35	15.459
193	Janie Hijlaard's Inka, 30852	" "	5- 0 26	" "	63	451.125	3.00	13.536
194	Debora's Inka, 30844	" "	5- 5-23	" "	24	509.000	3.08	15.667
195	Vrouwkje of Hijlaard 7th, 28449	" "	6- 1- 4	" "	38	441.625	3.04	13.427
196	Creamella 2d, 10725	" "	9-10-15	" "	39	472.250	3.12	14.757
197	Aaggie Grace 2d's Pietertje, 26731	A. W. Brown	6- 2-23	May 28, '97	34	651.750	2.89	18.803
198	Sadie Vale 2d, 18449	T. G. Yeomans & Sons	8- 3-14	Nov. 30, '97	27	340.250	3.40	11.656
199	Inka Pietertje Mechthilde, 30668	H. Stevens & Sons	5-10-29	Apr. 2. '98	35	409.938	3.08	12.614
200	Shadeland Angie, 21700	W. A. Matteson	8- 2-22	Apr. 17, '98	20	423.875	2.91	12.347
201	Sadie Vale Concordia, 32259*	T. G. Yeomans & Sons	5- 5- 3	Apr. 18, '98	18	542.313	3.09	16.772
202	Mutual Friend 3d, 28389*	" "	6- 6-26	" "	44	427.438	3.44	14.724
203	Princess of Wayne 7th, 28690	" "	6- 1-27	" "	38	491.438	3.17	15.600
204	Shadeland Ruby 5th, 29558	W. A. Matteson	6-11- 7	Apr. 19, '98	11	443.375	2.81	12.501
205	Vrouwkje of Hijlaard 7th, 28449	A. F. Cole	7- 0-26	May 19, '98	39	492.250	3.00	14.791
206	Jannek Bright 2d, 22943	Don J. Wood	8- 0-10	May 30, '98	69	448.875	3.28	14.730
207	Aaggie Grace's Boy's Topsy, 22946	" "	8- 0-13	" "	54	458.250	3.01	13.800
208	Jannek Beauty's Inka Pietertje, 28681	" "	7- 0- 1	" "	59	392.563	3.22	12.563
209	Segis Aaggie 2d's Pietertje, 32620	A. W. Brown	6- 0-25	June 6, '98	50	452.125	2.97	13.437
210	Shadeland Amber, 29330	W. A. Matteson	7- 1-18	June 25, '98	65	420.875	3.22	13.073

*Economic food test.

SUMMARY OF TABLE I.

A. AVERAGE PRODUCTION OF MILK AND FAT.

Age.	Number of cows.	Pounds of milk.	Per cent fat.	Pounds of fat.
AVERAGE FOR COWS TESTED WHILE AT PASTURE.				
Two-year-olds	47	282.531	3.07	8.680
Three-year-olds	19	363.431	3.18	11.541
Four-year-olds	23	418.905	3.09	12.947
Full aged cows	35	435.573	3.08	13.412
Average	124	363.419	3.09	11.245
AVERAGE FOR COWS TESTED WHILE NOT AT PASTURE.				
Two-year-olds	27	274.326	3.18	8.726
Three-year-olds	19	355.036	3.26	11.570
Four-year-olds	12	406.036	3.29	13.366
Full aged cows	28	458.362	3.27	14.975
Average	86	370.454	3.25	12.036
AVERAGE FOR ALL THE COWS TAKEN TOGETHER.				
Two-year-olds	74	279.537	3.11	8.697
Three-year-olds	38	359.234	3.22	11.555
Four-year-olds	35	414.493	3.16	13.091
Full aged cows	63	445.701	3.16	14.106
Average of all	210	366.300	3.16	11.569

B. LARGEST AND SMALLEST RECORDS OF COWS OF DIFFERENT AGES.

(The largest and smallest yields of milk and fat and the highest and lowest per cent of fat are indicated by heavy type.)

Age.	Largest records.				Smallest records.			
	No. in table I.	Pounds of milk.	Av'ge per cent fat.	Pounds of fat.	No. in table I.	Pounds of milk.	Av'age per cent fat.	Pounds of fat.
Two-year-olds	30	300.375	**4.22**	**12.675**	5	220.688	**2.29**	**5.268**
	62	**862.500**	2.69	9.764	57	**156.500**	3.39	5.301
Three-year-olds	76	•409.188	**4.27**	**17.472**	95	**228.625**	3.35	**7.665**
	101	**520.188**	3.06	15.903	96	316.375	**2.56**	8.091
Four-year-olds	121	427.938	**4.27**	**18.265**	117	**231.068**	3.03	**7.100**
	125	**521.250**	2.91	15.188	141	316.125	**2.78**	8.640
Full aged cows	174	544.875	**3.92**	**21.883**	155	**228.938**	3.83	**8.761**
	187	**654.125**	3.11	20.364	175	467.563	**2.52**	11.767

A close study of Table I and its summary reveals a large variation in production between animals of the same age. Among two-year olds the largest milk record for seven days is that of No. 62 (Lotty Moselle's Pietertje Mechthilde) with 362.5 pounds, containing 9.764 pounds of fat and an average fat content of 2.69 per cent. The lowest milk record is that of No. 57 with 156.5 pounds, containing 5.301 pounds of fat and an average fat content of 3.39 per cent. The largest production of fat is that of No. 31 (Pietertje Hengerveld's Lady De Kol) with 12.675 pounds from 300.375 pounds of milk containing an average of 4.22 per cent fat, which is the highest average found among the two-year olds The smallest production of fat is that of No. 5 with 5.263 pounds from 220.688 pounds of milk containing an average of 2.29 per cent fat, which is the lowest average found among two-year olds.

The average production for all two-year olds is 279.537 pounds of milk, 3.11 per cent fat and 8.697 pounds of fat.

Of the three-year olds No. 101 (America 2d's Pauline DeKol) leads in the production of milk with 520.188 pounds, containing 15.903 pounds of fat and an average of 3.06 per cent fat. The largest production of fat is by No. 76 (Mutual Friend 3d) with 17.472 pounds from 409.188 pounds of milk containing an average of 4.27 per cent fat which is the highest average found among four-year olds. No. 95 produced the smallest amount of both milk and fat, her record at this time being 228,625 pounds of milk and 7.665 pounds of fat. The lowest per cent of fat was given by No. 96 whose average was 2.56; her total milk and fat yield was 316.375 and 8.091 pounds respectively.

The average production for all three-year olds was 359.234 pounds of milk, 3.22 per cent of fat and 11.555 pounds of fat.

Among the four-year olds the one producing the most milk in seven days is No. 125 (Debora's Inka) with 521.25 pounds containing 15.188 pounds of fat and 2.91 per cent fat. The same heifer (Mutual Friend 3d) that led the three-year olds as No. 76 in total yield of fat and in average per cent fat, also leads, as No. 121, the four-year olds in the same respect. Her yield of fat was 18.265 pounds from 427.938 pounds of milk containing an average of 4.27 per cent fat, or exactly the same percentage her milk contained as a three-year old. No. 117 produced the smallest amount of both milk and fat, the former being 231.063 pounds and the latter 7.1 pounds. The lowest per cent of fat was given by No. 141 whose average was 2.73. Her total milk and fat yield was 316.125 and 8.64 pounds respectively.

The average production for four-year olds is 414.493 pounds of milk, 3.16 per cent fat and 13.091 pounds of fat.

Among the full aged cows No. 187 (Helena Burke) leads in milk production with 654.125 pounds containing 20.364 pounds of fat and an average of 3.11 per cent fat. The largest production of fat is by No. 174 (Netherland Hengerveld) with 21.333 pounds from 544.875 pounds of milk containing an average of 3.92 per cent fat which is the highest average found among full aged cows. The lowest record for milk and fat is by No. 155 with 228.938 pounds of milk and 8.761 pounds of fat and an average of 3.83 per cent fat. The lowest per cent of fat was given by No. 175 whose average was 2.52. Her yield of milk was 467.563 pounds and of fat 11.767 pounds.

The average production of full aged cows is 445.701 pounds of milk, 3.16 per cent fat and 14.106 pounds of fat.

It is interesting to note that in all ages but two-year olds the smallest production of milk and of fat fall to the same cow and at the same test,—No. 95 in three-year olds, No. 117 in four-year olds and No. 155 in full aged cows. Also, that in every age, the highest per cent of fat is accompanied with the highest total yield of fat, but in no case are these two accompanied by the largest total yield of milk. On the other hand, the lowest per cent of fat is accompanied by the smallest total yield in but one instance, and that among two-year olds.

The gain in production of the older animals over the younger shows a constant decrease as the age increases. The gain of three over two-year olds is 28.5 per cent in milk and 32.7 per cent in fat; of four over three-year olds is 12.6 per cent in milk and 18.2 per cent in fat; and of full aged cows over four year-olds is 7.5 per cent in milk and 7.7 per cent in fat.

COWS AT PASTURE AND NOT AT PASTURE.

Of the 210 separate tests made, 124 were of animals at pasture and which also received more or less grain. The remaining 86 cows were entirely stall fed. A study of the Summary of Table I shows a variation in production between those at pasture and those not at pasture. The number at pasture is considerably larger than the number not at pasture, and for this reason a comparison of averages does not carry so much weight as if there were the same number in each class, but because of the large number in each class we can draw conclusions that are fairly representative. Indeed the number of three-year olds at pasture is the same as those not at pasture and their records bear approximately the same relation to each other as do those of the two and four-year olds.

In production of milk, the average for two, three and four-year olds at pasture is greater than the average for the same ages among those not at pasture. On the other hand, the cows not at pasture have a higher average production of fat than those of corresponding ages at pasture. This is because the milk of the stall fed cows averages about one-tenth of one per cent higher in fat. When we come to the full aged cows the order is different, for here the stall fed cows average higher than those at pasture in production of milk as well as in total fat and per cent of fat. The difference in average production is 22.789 pounds of milk, 1.383 pounds of fat and .19 per cent fat. Taking the average of all the records we find the animals not at pasture exceed those at pasture in average weekly production by 7.035 pounds of milk, .791 pounds of fat and .16 per cent fat.

From these averages it would seem that there is a slight advantage in production to be obtained by judicious stall feeding over pasture feeding. Whether this results from feed alone or from weather and temperature effects is not determined. Some feeders prefer stall feed and cool, brisk winter weather for the best results. Others claim they can obtain better records in summer with rich pasture and bright, hot weather. Instances may be found which tend to show that both may be right. The matter may resolve itself into the question as to during which season the effects of temperature and weather upon the comfort of the cow can be best controlled. When cattle are kept in the stable, bad weather is expected and provisions are made to protect the animals from the elements, to keep them dry and warm, and to make their environment as uniform and comfortable as possible. Under such conditions the cow may be expected to do her best. On the other hand, with the cows at pasture no provision is usually made for feed in the stable, other than grain, and they are obliged to stay out-of-doors no matter what the weather. If it be warm and dry the cow is likely to do well, but if it be cool and damp, as is often the case during the early summer months, she cannot be expected to do her best. Extreme changes in temperature or continuous rainy weather with the cold, damp ground to lie on at night are not conditions calculated to be followed by large records. From our recollections of the tests we are led to say that possibly the majority of tests on pasture were made under unfavorable weather conditions. But few notes were taken on this point and thus no definite conclusions can be arrived at.

THE FOOD CONSUMED.

In Table II is given, after the name of the cow, the amount of each kind of grain and coarse fodder and the total pounds of grain and coarse fodder she consumed daily. Also the total amount of dry matter consumed during the seven days, the pounds of dry matter consumed for each one hundred pounds of milk and each pound of fat produced, and the nutritive ratio of the food. In the calculations of dry matter and nutritive ratio pasture is not included.

The data for compiling this table was obtained, in each case, from the statement of the owner or feeder of the animal as to what food she was receiving daily. It was usually based upon the actual weight of food consumed for some one day of the test. No attempt was made, except in the case of "Economic Food Tests," to secure official information as to the exact amount of food consumed by each animal, but we have every reason to believe that the statements made by the owners or feeders are substantially correct. We have seen no instance where there appeared to be any attempt to give the cow more food than the statement called for. We believe, therefore, that this table gives as accurate information concerning the food of each animal as could be obtained without actually weighing out daily each kind of grain and coarse fodder to be given her. For the cows entered in the "Economic Food Tests," to be described later, each day's ration was carefully weighed out by the supervisor of the test, and he was required to make affidavit, the same as for the milk and fat record, that, to the best of his knowledge, the cow received no other food than was named in the statement.

The names of the cows are arranged in the same manner as in Table I with the same numbers and in the same order as to time of test. Thus the reader can readily follow the same animal through the two tables, first to ascertain the amount of milk and butter fat she produced and second the quantity of food she consumed while producing it.

TABLE II.—AMOUNT AND KIND OF FOOD CONSUMED.

Number of test.	Name of cow.	Daily ration.												Dry matter consumed.			
		Grain.							Coarse fodder.								
		Wheat bran.	Corn meal.	Oats, ground.	Cotton-seed meal.	Oil meal.	Miscel-laneous.	Total grain.	Corn silage.	Hay.	Corn-stalks.	Miscel-laneous.	Total coarse fodder.	Total for seven days.	For 100 pounds of milk.	For 1 pou'd of fat.	Nutri-tive ratio.
1	Agnes DeKol's Ellen	3	1 3/7	3		1	o 4/7	9				Pasture		56.01			1:4.6
2	Inka Pietertje Mechthilde	3	1 3/7	3		1	o 4/7	9				"		56.01			1:4.6
3	Pieterje Kekke	3	1 3/7	3		1	o 4/7	9				"		56.01			1:4.6
4	DeKol's 2d's Pauline	3	1 3/7	3		1	o 4/7	9				"		56.01			1:4.6
5	Netherland Dot	6¾	4	3			b 3¾	17½				"		109.97			1:4.6
6	Netherland Clothilde Countess	6¾	4	3			b 3¾	17½				"		109 97			1:4.6
7	Idene Clothilde	6¾	4	3			b 3¾	17½				"		109.97			1:4.6
8	Sadie Vale Concordia	12¾	10½	5¾	4	4¼		37¼	25		5	S. 23	53	341.67	107.57	30.73	1:4.4
9	America 2d's Pauline Paul	11	9½	5	3¾	4		33¼	25		5	S. 21	51	312.62	126.56	45.27	1:4.7
10	America 2d's Pauline Paul	0	10	5	4½	4		33½	23		1½	S. 17½	42	288.12	121.85	42.49	1:4.2
11	Sadie Vale Concordia	0	10	5	4½	4		33½	23		1½	S. 17½	42	288.12	97.58	29.53	1:4.2
12	Pietertje Hengerveld 2d	8¾	3⅝	2		5⅝		20	40	10		P. 12	62	260.54	86.56	27.73	1:4.9
13	Pietertje Witkop's Mechthilde	3¼	2½	1½				7¼		2		Pasture		56.77			1:5.5
14	May De Kol	3¼	2½	1½				7¼		2		"		56.77			1:5.5
15	Lunde Beauty	3½	½	1	¾	½	b 1¼	7½				"		47.15			1:3.3
16	Clothilde Artis Lass	3½	½	1	¾	½	b 1¼	7½				"		47.15			1:3.3
17	Clothilde Artis Bright	3½	½	1	¾	½	b 1¼	7½				"		47.15			1:3.3
18	Clothilde Artis Belle	3½	½	1	¾	½	b 1¼	7½				"		47.15			1:3.3
19	Rag Apple's Clothilde Artis	3½	½	1	¾	½	b 1¼	7½				"		47.15			1:3.3
20	Pauline Paul Grant	7	4¼	4¼	5	5¼		25¾	37		4	S. 25	66	282.87	79.83	26.97	1:4.1
21	Sadie Pauline Paul	7	4¼	4¼	5	5¼		25¾	37		4	S. 25	66	282.87	97.75	30.13	1:4.1
22	Princess of Wayne 7th's Pauline	7	4¼	4¼	5	5¼		25¾	37		4	S 25	66	282.87	116.64	31.14	1:4.1
23	Princess Aaggie's Pauline DeKol	7	4¼	4¼	5	5¼		25¾	37		4	S. 25	66	282.87	116 35	35.81	1:4.1
24	Aaggie 3d's Wayne DeKol	7	4¼	4¼	5	5¼		25¾	37		4	S. 25	66	282.87	86.90	27.71	1:4.1

25	Prairie Flower's Pauline Paul 2d	10	5	5	5	4		29	30		7½	S. 34	71½	332.68	103.47	32.66	1:4.4
26	Mutual Friend's Pauline DeKol.	10	5	5	5	4		29	30		7½	S. 34	71½	332.68	138.83	38.96	1:4.4
27	Pauline Paul America 2d.......	10	5	5	5	4		29	30		7½	S. 34	71½	332.68	126.39	37.55	1:4.4
28	Inka Bess	5½	1½	1		3½	e1½	13		6		P. 8	Pasture.	128.59			1:4.2
29	Inka 8th	5½	1½	1		3½	e1½	13		6		P. 8	"	128.59			1:4.2
30	Inka DeKol	5½	1½	1		3½	e1½	13		6		P. 8	"	128.59			1:4.2
31	PietertjeHengerveld'sLdyDeKol	5½	1½	1		3½	e1½	13		6		P. 8	"	128.59			1:4.2
32	Snowball Clothilde	2⅗			⅘	⅕	r 5⅗	9				Pasture.		56.02			1:3.7
33	Clothilde Jannek Artis	2⅗			⅘	⅕	r 5⅗	9				"		56.02			1:3.7
34	Sweet Bough's Clothilde Artis..	2⅗			⅘	⅕	r 5⅗	9				"		56.02			1:3.7
35	Clothilde Artis Beauty	2⅗			⅘	⅕	r 5⅗	9				"		56.02			1:3.7
36	Clothilde Artis June	2⅗			⅘	⅕	r 5⅗	9				"		56.02			1:3.7
37	Clothilde Artis Topsy.........	2¾			⅞	¼	r6⅜	10¼				"		63.79			1:3.7
38	America 2d's Pauline DeKol ...	7	6½	3¾	3¾	3½		24½	36		6		42	230.65	68.98	24.69	1:4.5
39	America 2d's Pauline DeKol*...	2 3/7	2 6/7	1 5/7	1 1/7	1 1/7		10 1/7	60		3		63	166.02	54.39	16.53	1:6.0
40	Paul DeKol's Mutual Friend....	9	4½	2½	2	2		20	49		5½		54½	226.52	93.55	26.65	1:5.1
41	Paul DeKol 2d's Mutual Friend.	9	6	3¼	2	2	g1¼	23¼	49		5½		54½	248.43	103.00	30.90	1:5.0
42	Hartog Netherland 2d	5½				4	f5½	15	22	15		P. 30	67	260.05	89.48	29.92	1:5.9
43	Patty Waldorf.............[4th	5½				4	f5½	15	22	15		P. 30	67	260.05	106.57	34.14	1:5.9
44	Aaggie Constance's Netherland	8½	3	2		1¼	i2	16¾	35	8		P. 10	53	227.01	78.18	24.92	1:6.3
45	Netherland Wayne'sPaulinePaul	6	3¾	2	2	1¼		15	70	5			75	226.73	71.78	26.65	1:5.8
46	Clothilde Artis Aaggie Belle ...	2	1 2/7	1 2/7	2/7	1/7	b 4	9				Pasture.		56.30			1:3.7
47	Clothilde Artis Aaggie Bright...	2	1 2/7	1 2/7	2/7	1/7	b 4	9				"		56.30			1:3.7
48	Clothilde Artis Aaggie Lass	2	1 2/7	1 2/7	2/7	1/7	b 4	9				"		56.30			1:3.7
49	Clothilde Artis Constance	2	1 2/7	1 2/7	2/7	1/7	b 4	9				"		56.30			1:3.7
50	Clothilde Lunde Artis..........	2	1 2/7	1 2/7	2/7	1/7	b 4	9				"		56.30			1:3.7
51	Hetje 6th's Pietertje..........	3				2¼	f 3	8¼				P. 15	Pasture.	65.48			1:4.8
52	Waldorf Maid.................	3				2¼	f 3	8¼				P. 15	"	65.48			1:4.8
53	Pieterje Tweede	4				3	f 4	11				P. 30	"	106.57			1:5.2
54	Lily Netherland	2¼		2¼			b4½	9					"	56.95			1:3.5
55	Aaggie Grace Clothilde	2¼		2¼			b4½	9					"	56.95			1:3.5
56	Mutual Friend 3d's Pauline.....	8	7	4	4	1	g1	25	40		6		46	221.83	105.32	28.81	1:6.3
57	Sadie Pauline Paul 2d..........	8	7	4	4	1	g1	25	40		6		46	221.83	141.75	41.47	1:6.3
58	Plum DeKol....................	10		2			16	18	30	6		C. 15	51	204.82	91.64	31.80	1:6.0
59	Nannette 3d's Pledge 3d	10		2			16	18	30	6		C. 15	51	204.82	65.61	17.35	1:6.0
60	Aaggie 3d's Wayne's Pauline ...	4	5	3	1	1		14	50	6			56	196.28	60.28	20.98	1:6.0

*Economic food test.

Number of test.	Name of cow.	Daily rations.												Dry matter consumed.			
		Grain.							Coarse fodder.								
		Wheat bran.	Corn meal.	Oats ground.	Cotton-seed meal.	Oil meal.	Miscel-laneous.	Total grain.	Corn silage.	Hay.	Corn stalks.	Miscel-laneous.	Total coarse fodder.	Total for seven days.	For 100 pounds of milk	For 1 pou'd of fat.	Nutri-tive ratio.
61	Concordia 2d's Pauline...[thilde	4	7	4	2	2		19	56	6			62	236.53	99.28	35.64	1:5.5
62	Lotty Moselle's Pieterje Mech-	2 4/7	2 4/7			1 2/7	b 3 6/7	10 2/7				Pasture		64.44			1:3.3
63	Midland Gem................	1 6/7	1 6/7			1	b 2 5/7	7 3/7				"		46.54			1:3.3
64	Mechthilde of Midland........	2	2 1/7			1	b 3 1/7	8 2/7				"		51.91			1:3.3
65	Pietertje Mechthilde of Midland.	2¼	2¼			1⅛	b 3⅜	9				"		55.94			1:3.3
66	Hetje 6th's Mechthilde....	2¼	2¼			1⅛	b 3⅜	9				"		55.94			1.3.3
67	Shadeland DeKol...........	4	1	4	4	⅗	b 4	17⅗				"		111.16			1:2.3
68	Inka Hartog 2d....	4	1	4	4	⅗	b 4	17⅗				"		111.16			1:2.3
69	DeKol Lady.			1⅗			l 5⅕	6⅘				"		42.04			1:5.4
70	DeKol Manor Beets...........			1⅗			l 5⅕	6⅘				"		42.04			1:5.4
71	Tehee Clothilde...............	6¾			⅞	⅞	b 6¾	15				"		94.85			1:3.1
72	Aaggie Pietertje Clothilde.....	6¾			⅞	⅞	b 6¾	15				"		94.85			1:3.1
73	Clothilde Grace..............	6¾			⅞	⅞	b 6¾	15				"		94.85			1:3.1
74	Segis Clothilde Pietertje.......	5¼			¾	¾	b 5¼	12				"		75.88			1:3.1
75	Netherland Pietertje Princess..	3	1	3		1	o 1	9				"		53.34			1:4.6
76	Mutual Friend 3d.............	12	10½	6½	4¼	5		38¼	25		5	S. 23	53	347 83	85.00	19.91	1:4.4
77	Mutual Friend 3d............	10¾	10¾	5¼	4¾	4		35½	22		1½	S. 17½	41	300.65	84.58	23.60	1:4.2
78	Inka Pietertje Mechthilde.....	10¾	4⅜	2½		6⅜		24	40	10		P. 12	62	285 46	81.76	25.15	1:4.6
79	Pauline Paul Georgie.........	7	7	4	8	12		38	36	3		R. 40	79	394.17	114.29	34.56	1:3.3
80	DeKol 2d's Pauline	4½	4	2				10½		2		Pasture		76.86			1:5.6
81	Hetty W's Artis Clothilde......	3½	½	1	¾	½	b 1¼	7½				"		47.15			1:3.3
82	Sadie Vale Concordia....... ...	14	9	7½	7½	5¼		43¼	30		7½	S. 34	71½	423.33	102.12	29.22	1:3.9
83	Aaggie Lily 3d's Netherland....	9					b 4½	13½				Pasture		84.42			1:3.8
84	Black Maid Inka.... ...	2	2			2½	a 4	10½				P. 15	Pasture	88.06			1:3.7
85	Princess of Wayne 7th's Pauline.	9	6	4	4	2	g 1	26	77	5			82	305.83	93.52	25.87	1:5.0
86	Pauline Paul Grant...........	9	6	4	4	2	g 1	26	77	5			82	305.83	73.25	25.24	1:5.0

87	Princess Aaggie's Pauline DeKol	9	6	4	4	2	g 1	26	77	5			82	305.83	89.16	29.47	1:5.0
88	Clothilde Artis Topsy..........	2⅔	1½	1½	⅔	⅓	b 4⅓	11				Pasture		68.82			1:3.7
89	Clothilde Artis Raphaella ...	2⅔	1½	1½	⅔	⅓	b 4⅓	11				"		68.82			1:3.7
90	Clothilde Artis Pet.	2⅔	1½	1½	⅔	⅓	b 4⅓	11				"		68.82			1:3.7
91	Aaggie Lily 3d's Pietertje......	2¾		2¾			b 5½	11				"		69.58			1:3.5
92	Prairie Flower's Pauline Paul 2d.	11	8	6	6	2	g 1	34	60		7		67	338.80	109.07	38.30	1:4.7
93	Mutual Friend's Pauline DeKol.	11	8	6	6	2	g 1	34	60		7		67	338.80	98.16	28.67	1:4.7
94	Pauline Paul America 2d.......	11	8	6	6	2	g 1	34	60		7		67	338.80	98.06	30.54	1:4.7
95	Nannette 3d's Pledge 2d....	10		2			l 6	18	30	6		C. 15	51	204.82	89.58	26.72	1:6.0
96	Patty's Pet 3d............	4¼	4¼			2	a6½	17	50	20			70	298.62	94.42	36.91	1:4.9
97	Minnie Hijlaard............ ...	4¼	4¼			2	a6½	17	50	20			70	298 62	93.83	32.69	1:4.9
98	Patty Waldorf.........	4¼	4¼			2	a6½	17	50	20			70	298.62	81.99	27.62	1:4.9
99	Zady Bergsma................	10		2			l 6	18	30	6		C. 15	51	204.82	57.14	15.77	1:6.0
100	Paul DeKol's Mutual Friend.	7	9	5	2	1		24	56	6			62	267.47	71.72	22.37	1:5.8
101	America 2d's Pauline DeKol....	7	10	7	3	2		29	56	6			62	285.04	54 79	17.92	1:5.3
102	Mutual Friend 2d's Pauline....	4	7	4	2	2		19	56	6			62	236.53	78.11	24.21	1:5.5
103	Hetje 6th's Pietertje..........	2 4/7	2 4/7			1 2/7	b 3 6/7	10 2/7				Pasture		64.44			1:3.3
104	Clothilde Artis Belle 2d........	2				1	t 7	10				"		62.86			1:2.6
105	Clothilde Artis Aaggie Bright..		⅚	⅔	⅓		r8⅙	10				"		63.21			1:3.0
106	Clothilde Artis Aaggie Lass....		1⅔	1⅓	⅔		r6⅓	10				"		62.93			1:3.5
107	Clothilde Artis Constance......		1⅔	1⅓	⅔		r6¼	10				"		62.93			1:3.5
108	Clothilde Lunde Artis		1⅔	1⅓	⅔		r6⅓	10				"		62.93			1:3.5
109	Aaggie Grace Clothilde.......	9⅓			1⅙	1⅙	b 9⅓	21				"		131.79			1:3.1
110	Segis Aaggie Grace...........	6¾			⅞	⅞	b 6¾	15				"		94.85			1:3.1
111	Edith Grace..................	6¾			⅞	⅞	b 6¾	15				"		94.85			1:3.1
112	Leah Veeman 4th............	6					a 6	12				"		74.97			1:2.9
113	Medora Alice............. ..	2⅕	3⅕	3		1	o 1⅕	10⅗				"		66.94			1:5.3
114	Pietertje Hengerveld	2⅕	3⅕	3		1	o 1⅕	10⅗				"		66.94			1:5.3
115	Helena Burke..........	2⅕	3⅕	3		1	o 1⅕	10⅗				"		66.94			1:5.3
116	Inka 4th's Pietertje Rose......	1 5/7	2 3/7	2 3/7		6/7	o 6/7	8 2/7				"		51.59			1:5.3
117	Clothilde 3d's Clothilde	9½	6	4¾			b 5	25¼				"		158.76			1:4.6
118	Netherland Pietertje Hartog....	10¾	4⅜	2½		6⅜		24	40	10		P. 12	62	285.46	83.99	26.01	1:4.6
119	Magadora	4½	4	2				10½		2		Pasture		76.86			1:5.6
120	Netherland Pietertje Princess..	4½	4	2				10½		2		"		76.86			1:5.6
121	Mutual Friend 3d.............	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	80.79	18.93	1:3.7
122	Segis Aaggie 2d's Pietertje.....	9					b 4½	13½				Pasture		84.42			1:3.8

Number of test.	Name of cow.	Daily ration.												Dry matter consumed.			
		Grain.							Coarse fodder.								
		Wheat bran.	Corn meal.	Oats ground.	Cotton-seed meal.	Oil meal.	Miscel-laneous.	Total grain.	Corn silage.	Hay.	Corn-stalks.	Miscel-laneous.	Total coarse fodder.	Total for seven days.	For 100 pou'ds of milk.	For 1 pou'd of fat.	Nutri-tive ratio.
123	Vrouwkje of Hijlaard 8th	2	2			2½	a 4	10½				P. 15	Pasture	88.06			1:3.7
124	Rouble 5th's Pietertje	2	2			2½	a 4	10½				P. 15	"	88.06			1 3 7
125	Debora's Inka	3½	3½			3½	a 7	17½				P. 15	"	132.02			1:3.4
126	Patty's Pietertje Netherland	3½	3½			3½	a 7	17½				P. 15	"	132.02			1:3.4
127	Inka's Pietertje Netherland Beets	3½	3½			3½	a 7	17½				P. 15	"	132.02			1:3.4
128	Pauline Paul Georgie	14	8	4½	4½	4		35	92			Pasture.	92	352.52	80.56	25.55	1:2.3
129	Princess of Wayne 7th	14	8	4½	4½	4		35	92			"	92	352.52	76.69	26.21	1:2.3
130	Korndyke Queen	3½	4	9				16½				"		101.55			1:6.1
131	Creamella 2d's Topsy Ann	6				4½	f 6	16½	22	15		P. 30	67	269.50	65.39	25.25	1:5.8
132	Hartog Pietertje Netherland	6				4½	f 6	16½	22	15		P. 30	67	269.50	64.83	16.57	1:5.8
133	Clothilde Artis Belle	8½	3	2		1¼	i 2	16¾	35	8		P. 10	53	227.01	48.64	15.91	1:6.3
134	Sadie Vale Concordia	9	6	4	4	2	g 1	26	77	5			82	305.83	61.88	16.89	1:5.0
135	Hartog Pietertje Netherland*	2⅞		2¼			f 2⅞	8				P. 25	Pasture	82.18			1:5.4
136	Winana's Pietertje Netherland	2¾		2¾			b 5½	11					"	69.58			1:3.5
137	Catrina 4th's Pietertje Netherland	2¾		2¾			b 5½	11					"	69.58			1:3.5
138	Maplecroft Maid	10½	3	5½		1½	b 5½	26	25	8			33	247.24	62.04	20.57	1:4.1
139	Netherland Aaggie Madge	10½	3	5½		1½	h 5½	26	25	8			33	247.24	69.59	23.03	1:4.1
140	Belle of Schillaard 3d's Aaggie	10½	3	5½		1½	h 5½	26	25	8			33	247.24	81.65	23.30	1:4.1
141	Prisca	4¼	4¼			2	a 6½	17	50	20			70	298.62	94.46	34.56	1:4.9
142	Princess Aaggie's Pauline DeKol	7	9	5	2	1		24	56	6			62	267.47	55.91	18.49	1:5.8
143	Maplecroft Gem	7	2	4	4	2	n 7	26	25	8		C. 25	58	266.56	57.35	17 35	1:4.2
144	Sitje Twisk Pietertje	2 4/7	2 4/7			1 2/7	b 3 6/7	10 2/7				Pasture		64.44			1:3.3
145	Inka 8th			1 3/5			l 5 1/5	6 4/5				"		42.04			1:5.4
146	Clothilde Artis Topsy*						t 4	4				"		25.20			1:2.7
147	Segis Inka	7 9/16			15/16	15/16	b 7 9/16	17				"		107.46			1:3.1

148	Netherland Sada	2⅕	3⅕	3		1	o 1⅕	10⅗				Pasture		66.94			1:5.3
149	Bibiana's Pet	2⅕	3⅕	3		1	o 1⅕	10⅗				"		66.94			1:5.3
150	Aaggie B.	2⅕	3⅕	3		1	o 1⅕	10⅗				"		66.94			1:5.3
151	Netherland Hengerveld	2	3	2 5/7		6/7	o 1 1/7	9 5/7				"		60.93			1:5.3
152	Inka Hartog	2	3	2		1	1	9				"		55.37			1:5.3
153	Jessie Beets	2⅕	3⅕	3		1	o 1⅕	10⅗				"		66.94			1:5.3
154	7th Durkje Veeman's Ruby	2	3	2 5/7		1	o 1	9 5/7				"		60.93			1:5.3
155	Aegis 10th	9½	6	4¾			b 5	25¼				"		158.76			1:4.6
156	Clothilde 6th	9½	6	4¾			b 5	25¼				"		158.76			1:4.6
157	Idene Rooker	9½	6	4¾			b 5	25¼				"		158.76			1:4.6
158	Executrix Netherland	9½	6	4¾			b 5	25¼				"		158.76			1:4.6
159	Netherland Wayne	15	12	7	4¼	5		43¼	25		5	S. 30	60	392.49	90.02	30.74	1:4.5
160	Mutual Friend 2d	18	15	8	6½	6		53½	30		1½	S. 27½	59	432.82	73.97	21.00	1:4.2
161	Plum 4th	8¾	3⅝	2		5⅝		20	40	10		P. 12	62	260.54	62.18	16.78	1:4.9
162	Helena Burke	12¾	3⅝	2		5⅝		24	40	10		P. 12	62	311.81	60.16	20.66	1:4.1
163	Aaggie 3d's Wayne	7	7	4	8	12		38	36	3		R. 40	79	394.17	80.93	25.09	1:3.3
164	Inka Hartog	4½	4	2				10½		2		Pasture		76.86			1:5.6
165	Plum 4th	4½	4	2				10½		2		"		76.86			1:5.6
166	Netherland Wayne	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	77.44	27.71	1:3.7
167	Concordia 2d	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	73.57	22.75	1:3.7
168	Mutual Friend 2d's Wayne	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	65.91	19.32	1:3.7
169	Concordia 2d's America	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	88.06	29.88	1:3.7
170	Star's Netherland	9	5¾	5¾	8¾	5¾		35	37		4	S. 25	66	345.73	73.84	20.73	1:3.7
171	Aaggie 3d's Wayne	14	9	7½	7½	5¼		43¼	30		7½	S. 34	71½	423.33	85.17	25.53	1:3.9
172	Netherland VanFriesland Beets	6	2½	1½		3½	e 1½	15		6		P. 8	Pasture	141.05			1:4.4
173	Magadora	6	2½	1½		3½	e 1½	15		6		P. 8	"	141.05			1:4.4
174	Netherland Hengerveld	8	3	2		4	e 2	19		6		P. 8	"	165.76			1:4.3
175	Minnie Maria	9					b 4½	13½					"	84.42			1:3.8
176	Segis Aaggie 2d	9					b 4½	13½					"	84.42			1:3.8
177	Aaggie Grace 2d's Pietertje	13					f 5	18					"	113.61			1:4.0
178	Sweet Bough	3⅕			[illegible]	⅕	r 7⅗	12					"	74.69			1:3.7
179	Patty's Pet	3½	3½			3½	a 7	17½				P. 15	"	132.02			1:3.4
180	Maid of Eaton Inka	3½	3½			3½	a 7	17½				P. 15	"	132.02			1:3.4
181	Sadie Vale 2d	10	6	3	2⅖	2⅗		24	72		5		77	282.66	87.53	27.98	1:5.4
182	Mutual Friend 2d	12	9	5	5½	5		36½	72		5		77	358.12	60.95	17.69	1:4.6

*Economic food test.

Number of test.	Name of cow.	Daily ration.												Dry matter consumed.			
		Grain.							Coarse fodder.								
		Wheat bran.	Corn meal.	Oats ground.	Cotton-seed meal.	Oil meal.	Miscel-laneous.	Total grain.	Corn silage.	Hay.	Corn-stalks.	Miscel-laneous.	Total coarse fodder.	Total for seven days.	For 100 pounds of milk.	For 1 pou'd of fat.	Nutri-tive ratio.
183	Aaggie 3d's Wayne.*	3	3 3/7	1 6/7	1 5/7	1 5/7		11 5/7	73 2/7		5		78 2/7	208.20	50.78	14.09	1:6.3
184	Mutual Friend 3d	13	8½	4¾	3	3	g 1¼	33½	49		5½		54½	311.50	72.81	19.08	1:4.7
185	Patty's Pet	5½				4	f 5½	15	22	15		P. 30	67	260.05	57.34	16.05	1:5.9
186	Janie Hijlaard's Inka	5½				4	f 5½	15	22	15		P. 30	67	260.05	58.29	16.97	1:5.9
187	Helena Burke.	8½	4½	3		1¼	i 3	20¼	40	8		P. 10	58	249.97	38.21	12.11	1:6.4
188	Pauline Paul Georgie	9	6	4	4	2	g 1	26	77	5			82	305.83	81.31	23.85	1:5.0
189	Princess of Wayne 7th	9	6	4	4	2	g 1	26	77	5			82	305.83	65.69	20.83	1:5.0
190	Mutual Friend 3d*	2½	2	1½	1	1		8	70	4			74	176.33	48.51	14.46	1:6.6
191	Aaggie Grace's Boy's Topsy	2⅔	1½	1½	⅔	⅓	4⅓	11					Pasture	68.82			1:3.7
192	Patty's Pet*	3⅝				2¾	f 3⅝	10				P. 25	"	93.52			1:5.1
193	Janie Hijlaards Inka	4				3	f 4	11				P. 30	"	106.57			1:5.2
194	Debora's Inka	4				3	f 4	11				P. 30	"	106.57			1:5.2
195	Vroukje of Hijlaard 7th	3				2¼	f 3	8¼				P. 15	"	65.48			1:4.8
196	Creamella 2d	4				3	f 4	11				P. 30	"	106.57			1:5.2
197	Aaggie Grace 2d's Pietertje	5		5			f 10	20					"	126.56			1:3.5
198	Sadie Vale 2d	11	7	4	4	2		28	60		6		66	295.47	86.84	25.35	1:5.1
199	Inka Pietertje Mechthilde	10		3			l 10	23	30	6		C. 15	51	234.64	57.24	18.60	1:5.8
200	Shadeland Angie.	8	2½	5		2½	d 8	26	25	8		C. 25	58	265.09	62.54	21.48	1:5.5
201	Sadie Vale Concordia*	6 3/7	8 3/7	5 3/7	4	4		28 2/7	66	7			73	315.13	58.11	18.79	1:4.9
202	Mutual Friend 3d*	6 3/7	2 1/7	5/7	½			9 11/14	62	5 1/7			67 1/7	179.24	41.93	11.49	1:6.6
203	Princess of Wayne 7th	7	10	7	3	2		29	56	6			62	285.04	58.00	18.27	1:5.3
204	Shadeland Ruby 5th	7	2	4	4	2	n 7	26	25	8		C. 25	58	266.56	60.12	21.32	1:4.2
205	Vrouwkje of Hijlaard 7th	2¼	2¼			1⅛	b 3⅜	9				Pastnre		55.94			1:3.3
206	Jannek Bright 2d		2	1 3/5	4/5		r 7 3/5	12				"		75.46			1:3.5
207	Aaggie Grace's Boy's Topsy		2	1 3/5	4/5		r 7 3/5	12				"		75.46			1:3.5
208	Jannek Beauty's Inka Pietertje		2	1 3/5	4/5		r 7 3/5	12				"		75.46			1:3.5
209	Segis Aaggie 2d's Pietertje	6¼			⅞	⅞	b 6¾	15				"		94.85			1:3.1
210	Shadeland Amber	6					a 6	12				"		74.97			1:2.9

* Economic food test.

Foods mentioned under the head of "Miscellaneous" in Table II are indicated as follows: a. Gluten meal; b. Gluten feed; c. Pea meal; d. Buckwheat, ground; e. Barley; f. Hominy chop; g. Linseed bran; h. Buckwheat feed; i. Peas and barley ground; l. Peas, barley and buckwheat; n. Peas and buckwheat; o. Rye; r. Gluten feed, malt sprouts and hominy chop; t. Gluten feed and malt sprouts; C. Carrots; P. Potatoes; S. Clover silage; R. Green clover.

SUMMARY OF TABLE II.

A. Showing the Varying Production from same Amounts and Kinds of Food by Animals of Similar Ages.

Number in tables I and II.	Age.	Total dry matter consumed.	Total pounds of milk.	Average per cent fat.	Total pounds of fat.	Dry matter for 100 pounds milk.	Dry matter for 1 pound. fat.
20	2	282.87	354.188	2.96	10.478	79.83	26.97
23	2	282.87	243.125	3.24	7.879	116.35	35.81
95	3	204.82	228.625	3.35	7.665	89.58	26.72
99	3	204.82	358.438	3.62	12.978	57.14	15.77
138	4	247.24	398.500	3.01	12.015	62.04	20.57
140	4	247.24	302.813	3.52	10.648	81.65	23.30
168	5	345.73	524.563	3.41	17.888	65.91	19.32
169	5	345.73	392.563	2.95	11.568	88.06	29.88

B. Showing the Varying Production from Similar Amounts of Food by Animals of Different Ages.

10	2	288.12	236.438	2.87	6.780	121.85	42.49
24	2	282.87	325.500	3.15	10.209	86.90	27.71
98	3	298.62	364.188	2.97	10.810	81.99	27.62
101	3	285.04	520.188	3.06	15.903	54.79	17.92
118	4	285.46	339.875	3.23	10.972	83.99	26.01
143	4	266.56	464.750	3.30	15.357	57.35	17.35
181	7	282.66	322.813	3.13	10.099	87.53	27.98
203	6	285.04	491.438	3.17	15.600	58.00	18.27

C. SHOWING THE VARYING QUANTITIES OF FOOD REQUIRED TO PRODUCE SIMILAR AMOUNTS OF BUTTER FAT IN DIFFERENT ANIMALS.

Number in tables I and II.	Age.	Total pounds of fat.	Total dry matter consumed.	Total pounds of milk.	Average per cent fat.	Dry matter for 100 pounds of milk.	Dry matter for 1 pound fat.
26	2	8.538	332.68	239.625	3.56	138.83	38.96
45	2	8.508	226.73	315.875	2.69	71.78	26.65
92	3	8.846	338.80	310.625	2.85	109.07	38.30
44	2	9.111	227.01	290.375	3.14	78.18	24.92
22	2	9.082	282.87	242.500	3.75	116.64	31.14
8	2	11.116	341.67	317.625	3.50	107.57	30.73
59	2	11.747	204.82	312.188	3.76	65.61	17.35
78	3	11.348	285.46	349.125	3.25	81.76	25.15
79	3	11.406	394.17	344.875	3.30	114.29	34.56
161	6	15.519	260.54	419.000	3.70	62.18	16.78
163	7	15.705	394.17	487.063	3.22	80.93	25.09
160	7	20.608	432.82	585.125	3.52	73.97	21.00
187	7	20.364	249.97	654.125	3.11	38.21	12.11

D. SHOWING THE VARYING QUANTITIES OF FOOD REQUIRED TO PRODUCE THE LARGEST AMOUNTS OF MILK IN ANIMALS OF DIFFFRENT AGES.

Number in tables I and II.	Age.	Total pounds of milk.	Total dry matter consumed.	Total pounds fat.	Average per cent fat.	Dry matter for 100 pounds milk.	Dry matter for 1 pound fat.
20	2	354.188	282.87	10.487	2.96	79.83	26.97
38	2	334.395	230.65	9.339	2.79	68.98	24.69
82	3	414.500	423.33	14.485	3.50	102.12	29.22
101	3	520.188	285.04	15.903	3.06	54.79	17.92
133	4	466.750	227.01	14.272	3.05	48.64	15.91
134	4	494.250	305.83	18.103	3.66	61.88	16.89
160	7	585.125	432.82	20.608	3.52	73.97	21.00
162	5	518.250	311.81	15.089	2.91	60.16	20.66
168	5	524.563	345.73	17.888	3.41	65.91	19.32
182	9	589.250	358.12	20.242	3.44	60.95	17.69
187	7	654.125	249.97	20.364	3.11	38.21	12.11

E. SHOWING LARGEST AND SMALLEST QUANTITIES OF FOOD REQUIRED TO PRODUCE 100 POUNDS OF MILK IN DIFFERENT ANIMALS EXCLUSIVE OF "FOOD TESTS."

Number in tables I and II.	Age.	Dry matter for 100 pounds of milk.	Total dry matter consumed.	Dry matter for 1 pound of fat.	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
57	2	141.75	221.83	41.47	156.500	3.39	5.301
60	2	60.28	196.28	20.98	325.625	2.87	9.354
79	3	114.29	394.17	34.56	344.875	3.30	11.406
101	3	54.79	285.04	17.92	520.188	3.06	15.903
141	4	94.46	298.62	34.56	316.125	2.73	8.640
133	4	48.64	227.01	15.91	466.750	3.05	14.272
159	5	90.02	392.49	30.74	436.000	2.93	12.767
187	7	38.21	249.97	12.11	654.125	3.11	20.364

F. SHOWING THE LARGEST AND SMALLEST QUANTITIES OF FOOD REQUIRED TO PRODUCE ONE POUND OF FAT IN DIFFERENT ANIMALS EXCLUSIVE OF "FOOD TESTS."

Number in tables I and II.	Age.	Dry matter for 1 pound of fat.	Total dry matter consumed.	Dry matter for 100 pounds of milk.	Total pounds of milk.	Average per cent fat.	Total pounds of fat.
9	2	45.27	312.62	126.56	247.000	2.80	6.906
59	2	17.35	204.82	65.61	312.188	3.76	11.747
92	3	38.30	338.80	109.07	310.625	2.85	8.846
99	3	15.77	204.82	57.14	358.438	3.62	12.978
118	4	26.01	285.46	83.99	339.875	3.23	10.972
133	4	15.91	227.01	48.64	466.750	3.05	14.272
159	5	30.74	392.49	90.02	436.000	2.93	12.767
187	7	12.11	249.97	38.21	654.125	3.11	20.364

G. SHOWING THE AVERAGE PRODUCTION AND CONSUMPTION OF ALL ANIMALS TESTED WHILE NOT AT PASTURE AND OF EACH AGE SEPARATELY.

	No. of animals.	Milk.	Per cent fat.	Pounds fat	Dry matter consumed.	Dry matter for 100 pounds milk.	Dry matter for 1 pound fat.
Two-year olds.	27	274.326	3.18	8.726	260.55	94.98	29.86
Three-year olds	19	355.036	3.26	11.570	304.20	85.68	26.29
Four-year olds.	12	406.036	3.29	13.366	273.12	67.06	20.43
Full aged cows	28	458.362	3.27	14.975	303.70	66.26	20.28
Average of all	86	370.454	3.25	12.036	286.00	77.20	23.76

H. ECONOMIC FOOD TESTS.

Number in tables I and II.	Age.	Total pounds of milk.	Average per cent fat.	Total pounds of fat.	Total dry matter consumed.	Dry matter for 100 pounds milk.	Dry matter for 1 pound fat.
39	2	305.188	3.32	10.043	166.02	54.39	16.53
183	9	410.000	3.64	14.773	208.20	50.78	14.09
190	5	363.875	3.34	12.184	176.33	48.51	14.46
201	5	542.313	3.09	16.772	315.13	58.11	18.79
202	6	427.438	3.44	14.724	179.24	41.93	11.49

There is much variation in the amount of food eaten by different animals during a test, and a close study of Tables I and II will be of interest and value to every cattle feeder: Study Table I to see what a particular cow produced in a week and Table II to find what she ate during the same time. The cows tested while at pasture were all given more or less grain, and the amounts vary from 6⅘ to 17⅗ pounds per day for two-year olds; from 7½ to 21 pounds for three-year olds; from 6⅘ to 25¼ pounds for four-year olds; and from 9 to 25¼ pounds for full aged cows. The cows tested while on stall feed naturally ate more grain and these amounts vary from 14 to 37¼ pounds for two-year olds; from 18 to 43¼ pounds for three-year olds; from 16¾ to 35 pounds for four-year olds, and from 15 to 53½ pounds for full aged cows. In amount of coarse fodder eaten daily, two-year olds vary from 42 to 71½ pounds; three-year olds from 41 to 71½ pounds, four-year olds from 33 to 92 pounds; and full aged cows from 54½ to 82 pounds. Animals under "Economic Food Test" are not included in the above.

Such large rations of grain and of coarse fodder are, no doubt, surprising to the general dairyman, and he will gravely question the economy of feeding so heavily. However, the question with the men who have entered their cows in these tests is not one of economy so much as it is of forcing the cow to produce as much milk and butter as possible. In order to do this, a large amount of food is necessary, and the more food she can consume and digest the larger product she is apt to give. The fame the cow brings to the herd and the prize she wins, and not the milk and butter, are to pay for the food. It is a question whether the "Economic Food Test," where the attempt is to feed as little and produce as much as possible, is a step in the right direction. Would it not be a better principle to, in some way, bring out those animals which can make the most economic use of *large* amounts of food?

Under the head of "Summary of Table II" we have gathered such data as will show the great variation in production from the same or similar amounts of food when given to different animals. As a matter of convenience, when referring to the figures in the summary we shall omit fractions as much as possible and speak in round numbers.

Under A are arranged two animals from each of the various ages which consumed the same amounts of the same kinds of food, together with their production of milk and fat. Each two animals were in the same herd and were tested at the same time. Of the two-year olds, numbers 20 and 23 each consumed 282.87 pounds of dry matter, but in production No. 20 exceeds No. 23 by about 111 pounds of milk, or 45 per cent, and over 2.5 pounds of fat, or 33 per cent. Number 20 also required 36.5 pounds less of dry matter for 100 pounds of milk and nearly 9 pounds less of dry matter for 1 pound of fat than No. 23. Of the three-year olds numbers 95 and 99 each consumed 204.82 pounds of dry matter. The difference in production is about 130 pounds of milk or 57 per cent, and 5.3 pounds of fat or 69 per cent in favor of No. 99. The latter required about 32 pounds less of dry matter for 100 pounds of milk and 11 pounds less of dry matter for 1 pound of fat than No. 95.

Among the four-year olds numbers 138 and 140 each consumed 247.24 pounds of dry matter. From this No. 138 produced 95 pounds or 31 per cent more of milk and 1.367 pounds or 13 per cent more of fat than No. 140. Number 138 also required 19.6 pounds less of dry matter for 100 pounds of milk and 2.7 pounds less of dry matter for 1 pound of fat than No. 140.

Of the full aged cows numbers 168 and 169 each consumed 345.73 pounds of dry matter, but No. 168 produced 132 pounds or 33 per cent more of milk amd 6.32 pounds or 54 per cent more of fat than No. 169. Number 168 required 23 pounds less of dry matter for 100 pounds of milk and 10.5 pounds less of dry matter for 1 pound of fat.

Under B are arranged the records of eight cows selected from the various ages, each of whom consumed in the neighborhood of 285 pounds of dry matter. In production they vary from 236 to 520 pounds of milk and from 6.78 to 15.9 pounds of fat, or a variation of 120 per cent in milk and of 134 per cent in fat. In the amount of dry matter required for 100 pounds of milk they vary from 55 to 122 pounds or 122 per cent, and for 1 pound of fat from 17.35 to 42.5 pounds or 145 per cent.

Under C is collected some data showing the varying amounts of food required to produce similar amounts of butter-fat in different animals. For the production of about 8.5 pounds of butter-fat in two-year olds, the dry matter varies from 226 to 332 pounds, a difference of 46 per cent. To produce a little over 11 pounds of fat is required a quantity of dry matter varying from 204 to 341 pounds, a difference of 67 per cent. For a similar amount of fat among three-year olds, the consumption of dry matter varies from 285 to 394 pounds, a difference of 38 per cent.

Among full aged cows the amount of dry matter required to produce about 15.5 pounds of fat varies from 260 to 394 pounds, a difference of 51 per cent. To produce a little more than 20 pounds of fat, the variation is still greater, being the difference between 250 and 433 pounds or 73 per cent.

Under D are arranged the records of the cows which gave the most milk for their age of those that were stall fed. Among two-year olds a difference of a little less than 20 pounds of milk is accompanied with a difference of over 52 pounds of dry matter, the heifer consuming the most food giving the most milk. This order is reversed among three-year olds where a difference in milk yield of a little more than 105 pounds, is accompanied with a difference of over 138 pounds or 48 per cent of dry matter consumed, but the heifer consuming the larger amount of food gave the less milk yield. The variation among four-year olds in milk yield is 27½ pounds and in dry matter consumed a little over 78 pounds, or 34 per cent, and the cow giving more milk also consumed the larger amount of food. Five records of old cows are given. In milk production these vary from 518 to 654 pounds, and these same two records vary in dry matter consumed from 312 to 250 pounds respectively. Here again, as among the three-year olds, the larger yield of milk is accompanied with the smaller consumption of food. It should be added that these two records were made by the same cow, Helena Burke, one at five years of age and the other at seven. She shows a better capacity for the economic use of food at seven than at five. Indeed, she and No. 101, America 2d's Pauline DeKol among three-year olds are remarkable animals in this respect as well as in the large records they have made for milk and butter.

Under E we have a vivid comparison of the largest and smallest amounts of food required to produce 100 pounds of milk in different animals. Among the two-year olds No. 57 required 141 pounds of dry matter to produce 100 pounds of milk, which is the most required by any cow of any age. It may be said in her favor that she was not in good condition. She was so hard a milker that it was necessary to use the knife to enlarge the orifices of the teats which were not healed at the time of test, thus rendering the milking operation very uncomfortable to her and doubtless reducing the quantity. The two-year old requiring the smallest amount of dry matter for 100 pounds of milk is No. 60 The difference between the largest and smallest amounts is 81 pounds or 135 per cent. In like manner, we find that the difference between the largest and smallest amounts required by three-year olds is 60 pounds or 180 per cent, by four-year olds about 46 pounds or 94 per cent, and by full aged cows nearly 52 pounds or 136 per cent.

Under F are shown the largest and smallest amounts of food required to produce one pound of fat in different animals at various ages. For two-year olds the difference between these amounts is about 28 pounds of dry matter or 160 per cent, for three-year olds 21.5 pounds or 136 per cent, for four-year olds 10 pounds or 63 per cent, and for full aged cows over 18 pounds or 154 per cent.

Summing up the observations under E and F, we find the order of the per cent of variation from the largest to the smallest amounts of food required by different animals of the same age, is the same in regard to the production of fat as in the production of milk, namely, the largest variation is found among two year olds, next come full aged cows, then three-year olds, and the least variation is among four-year olds. As regards the variation in actual pounds of dry matter, the order is, two and three-year olds, full aged cows and last, four-year olds.

Three cows are named in both E and F. Number 133, Clothilde Artis Belle has the distinction of requiring less food for 100 pounds of milk and also for one pound of fat than any other four-year old. Number 159, Netherland Wayne, required more food for the same amount of milk and fat than any other aged cow. Number 187, Helena Burke, required less food for the same amount of milk and fat than any other aged cow.

Under G are given the average production and consumption of all the animals that were tested on stall feed. In the order of production of milk and fat they stand in the order of age, the two-year olds averaging the least and the full aged cows the most. In average consumption of food, however, the three-year olds are the highest, being a trifle more than full aged cows, after which follow four and two-year olds respectively. In amount of dry matter for 100 pounds of milk and one pound of fat, full aged cows require the least and are followed successively by four, three and two-year olds. From these averages it would seem that full aged cows lead in economic production although they are so closely followed by four-year olds as to make the difference of little or no account.

"ECONOMIC FOOD TESTS."

Under H are arranged the records of five cows that were entered in the "Economic Food Tests." The Holstein-Friesian Association gives prizes to the cows producing butter at the least cost per pound for food. A list of all the more common cattle foods with a schedule of prices is given, and each breeder is at liberty to choose any of these with which he thinks he can produce butter the cheapest through his particular animal. These prizes have been offered for only two years and in this state six cows have been entered for them. One cow, No. 146, was entered on grass and her record does not appear in our list because no just comparison can be made as to the amount of dry matter consumed which is the basis of this comparison. Numbers 190 and 202 refer to the same cow, Mutual Friend 3d, she being tested in two successive years. On her last test she consumed the least amount of food for one pound of fat that has been required by any cow of any age whose record is given in this bulletin. It will be remembered under F that No. 187 required the least dry matter for 100 pounds of milk and one pound of fat of any cow not on an "Economic Food Test." This is only a little more food for a pound of fat than was required by No. 202, and the former was not entered for a food test, but it was intended to give her all the food she could well handle. This is well shown in tabular form below.

		Food consumed per day.		Dry matter consumed.	
		Forage.	Grain.	For 100 lbs. milk.	For 1 lb fat.
No. 202.	Mutual Friend 3d .... (On Economic Food Test)	67 1/7	9 11/14	41.93	11.49
No. 187.	Helena Burke .... (Cow requiring least dry matter for 1 lb. product)	58	20¼	38.21	12.11
No. 160.	Mutual Friend 2d .... (Cow consuming most dry matter per day.)	59	53½	73.97	21
	Average for all cows not at pasture			77.20	23.76

On the food test, the only two-year old entered required 16.53 pounds of dry matter for one pound of fat. This is a little more than was required by the three- and four-year olds, numbers 99 and 133 respectively, and only a little less than by No. 59 of the two-year olds. Neither of the three last named were entered on food tests. The cow requiring the most dry matter for one pound of fat among those entered for food tests is No. 201, with 18.79 pounds. It will be noticed, however, that she consumed a large total amount of food, it being 315.13 pounds. Had she given milk of as high a per cent of fat as when a four-year old, No. 134, or when a three-year old, No. 82, she would have produced her fat much cheaper.

VARIATION IN PER CENT FAT.

Table III contains such data as could be obtained from the records concerning the per cent of fat and its variation in different animals. Each record given here bears the same number as corresponds to the animal in Tables I and II which bears that record. The data given contains the number of days from calving to the beginning of the test, the average per cent of fat for the week, the highest per cent of fat, the time of day at which it was obtained, and the number of hours which elapsed between that time and the previous milking; also the same data concerning the lowest per cent of fat, and the range of variation in per cent of fat.

TABLE III.

VARIATION IN PER CENT OF FAT.

A. Two-Year Olds.

No. in tables I and II.	Days from calving.	Av'ge per cent fat	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN 1 TO 15 DAYS FROM CALVING.									
5	7	2.29	3.45	night.	5	1.40	morn.	11¼	2.05
30	11	3.24	3.90	"	6	2.30	"	9½	1.60
36	15	3.24	3.80	noon.	7	2.90	night.	7½	.90
50	15	3.34	3.90	"	7½	2.80	morn.	9½	1.10
51	6	3.48	3.80	"	7	3.30	morn and night	8, 9	.50
Average		3.12							1.23
TESTS WHICH BEGAN 16 TO 30 DAYS FROM CALVING.									
7	28	2.76	3.60	night.	5	2.00	noon.	7¼	1.60
8	28	3.50	3.90	noon.	7⅛	3.20	morn and night	9, 7½	.70
9	24	2.80	3.20	"	7½	2.50	night and morn	9, 7½	.70
12	26	3.12	4.20	"	7	1.90	morn.	10	2.30
22	22	3.75	5.25	"	7½	3.05	"	9½	2.20
23	21	3.24	4.40	"	7½	2.50	"	9½	1.90
24	25	3.15	3.70	night.	7	2.60	noon.	7½	1.10
25	20	3.17	3.70	"	7	2.80	morn.	9½	.90
28	24	2.82	3.60	"	6	2.10	"	9½	1.50
31	16	4.22	4.80	"	6	3.70	morn and noon.	9½	1.10
36	21	2.79	3.55	noon.	7½	2.15	morn.	9	1.40
44	23	3.14	3.70	midnight.	6	2.70	6 a. m.	6	1.00
48	26	3.21	3.70	noon.	7½	2.70	morn.	9½	1.00
46	27	3.46	4.10	noon.	7½	2.90	"	9½	1.20
52	18	2.37	2.70	noon and morn.	7, 9	2.10	night.	8	.60
56	20	3.65	5.10	night.	7	1.70	morn.	9	3.40
59	30	3.76	5.00	"	7	2.40	"	9	2.60
60	30	2.87	3.40	10 a. m.	6	2.30	4 p. m.	6	1.10
69	23	3.00	5.20	noon.	7	2.00	morn.	9	3.20
65	30	2.74	4.40	"	8	1.80	"	9	1.60
67	22	2.86	3.60	morn.	8	1.60	noon.	8	2.00
68	21	2.99	4.10	"	8	2.20	morn.	8	1.90
Average		3.15							1.59
TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.									
2	36	3.08	4.00	night.	5½	2.10	morn.	10½	1.90
3	43	3.00	4.50	"	5½	1.70	"	10½	2.80
6	32	3.00	3.65	"	5	2.20	noon.	7¾	1.45
10	49	2.87	3.40	noon.	7½	2.20	morn.	9	1.20
11	53	3.30	3.80	"	7½	2.80	night.	7½	1.00
13	34	2.90	4.85	"	7	2.00	morn.	9	2.85

TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.—*Continued.*

No. in tables I and II.	Days from calving.	Av'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
14	40	2.95	3.10	morn and noon.	9, 7	2.70	night.	8	.40
15	42	3.35	3.85	noon.	6½	2.90	morn.	10	.95
17	51	3.20	4.00	"	6½	2.45	"	10	1.55
19	58	3.45	4.10	"	6½	3.05	"	10	1.05
21	48	3.24	3.80	"	7½	2.80	"	9½	1.00
26	51	3.56	4.80	night.	7	3.00	"	9½	1.80
27	57	3.37	4.00	night and noon	7, 7½	2.80	"	9½	1.20
29	47	3.15	4.30	night.	6	2.30	"	9½	2.00
47	34	3.47	4.40	noon.	7½	2.40	"	9½	2.00
49	46	3.05	3.80	"	7½	2.30	"	9½	1.50
45	40	2.69	3.30	night.	7	2.30	morn and noon	9½, 7½	1.00
53	35	2.92	3.50	noon.	7	2.40	night.	8	1.10
57	49	3.39	3.70	night.	7	3.00	morn.	9	.70
58	55	2.88	3.60	"	7	2.40	"	9	1.20
70	31	3.16	5.40	noon.	7	1.80	"	9	3.60
63	45	2.68	3.10	"	8	2.30	"	9	.80
64	46	2.79	3.40	"	8	2.30	"	9	1.10
66	38	3.07	4.80	"	8	2.40	night.	7	2.40
71	40	2.86	3.30	"	7	2.60	night and morn	8, 9	.70
72	50	3.13	3.60	morn.	9	2.80	night.	8	.80
73	50	2.95	4.00	noon.	7	2.30	morn.	9	1.70
74	47	2.87	3.80	"	7	2.50	"	9	1.30
62	41	2.69	3.00	"	8	2.30	"	9	.70
Average		3.07							1.44

TESTS WHICH BEGAN MORE THAN 60 DAYS FROM CALVING.

No. in tables I and II.	Days from calving.	Av'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
1	81	3.36	3.75	noon.	8	2.85	morn.	10½	.90
4	63	3.72	4.60	night.	5½	2.50	"	10½	2.10
16	61	3.25	3.50	"	7½	3.00	noon.	6½	.50
18	61	3.40	4.75	"	7½	2.50	morn.	10	2.25
20	68	2.96	3.60	"	7	2.30	"	9½	1.30
32	97	2.66	3.10	noon.	7	2.40	"	9½	.70
33	74	3.13	3.70	"	7	2.80	"	9½	.90
34	78	2.93	3.60	"	7	2.60	"	9½	1.00
35	84	3.28	4.20	"	7	2.90	"	9½	1.30
37	86	3.01	3.40	"	7	2.70	"	9½	.70
39	105	3.32	4.50	"	8	2.70	"	9	1.80
40	72	3.50	4.70	night.	7	2.80	"	9	1.90
41	85	3.32	3.90	"	7	2.80	"	9	1.10
42	85	2.96	3.80	noon.	7½	2.40	"	9	1.40
43	90	3.12	3.40	"	7½	2.80	"	9	.60
54	112	2.91	3.90	"	8	2.00	"	10	1.90
55	107	3.17	3.80	"	8	2.60	"	10	1.20
61	84	2.79	3.40	10 p. m.	6	2.40	4 p. m.	6	1.00
Average		3.15							1.25
" all 2 yr. olds.		3.12							1.42

B. Three-Year Olds.

No. in tables I and II.	Days from calving.	Av'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN 1 TO 15 DAYS FROM CALVING.									
75	5	4.24	5.40	noon.	8	3.70	morn.	10½	1.70
78	11	3.25	4.00	night.	7	2.10	"	10	1.90
79	15	3.30	3.90	"	7	2.85	night.	7	1.05
80	12	3.45	4.70	noon.	7	2.40	morn.	9	2.30
91	12	2.94	4.30	night.	6	2.30	"	10	2.00
105	14	3.96	5.10	noon.	7	3.50	"	9½	1.60
Average		3.52							1.76
TESTS WHICH BEGAN 16 TO 30 DAYS FROM CALVING.									
76	17	4.27	4.90	noon.	7½	3.60	morn.	9	1.30
88	30	3.21	3.70	"	7½	2.30	"	9½	1.40
85	18	3.61	4.20	"	7½	3.10	"	9½	1.10
99	25	3.62	5.20	night.	7	2.00	"	9	3.20
98	17	2.97	3.20	noon and night	7, 8	2.60	noon.	8	.60
100	27	3.18	3.80	10 p. m.	6	2.60	10 a. m.	6	1.20
101	27	3.06	4.00	"	6	2.40	4 p. m.	6	1.60
104	21	3.12	3.60	noon.	7	2.80	night.	7½	.80
106	25	3.19	3.50	"	7	2.90	morn.	9½	.60
109	20	3.20	3.90	"	7	2.80	night.	8	1.10
110	27	3.44	4.40	"	7	2.70	morn	9	1.70
112	23	2.75	3.40	6 a. m.	6	2.00	6 p. m.	6	1.40
Average		3.30							1.33
TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.									
77	42	3.59	4.40	noon.	7½	2.80	morn.	9	1.60
82	56	3.50	4.00	night.	7	2.90	"	9½	1.10
83	50	3.08	3.55	morn.	8	2.55	noon.	8½	1.00
89	58	2.90	4.10	noon.	7½	2.20	morn.	9½	1.90
90	48	3.08	4.00	"	7½	1.70	"	9½	2.30
86	47	2.90	4.00	night.	7	2.10	"	9½	1.90
87	51	3.02	3.80	"	7	2.20	"	9½	1.60
92	45	2.85	3.50	"	7	2.60	"	9	.90
94	55	3.18	3.70	"	7	2.90	"	9	.80
96	31	2.56	3.20	"	7	2.00	"	9	1.20
97	31	2.84	3.60	noon.	8	2.10	"	9	1.50
103	41	2.89	3.50	"	8	2.10	"	9	1.40
107	38	3.11	3.50	"	7	2.70	"	9½	.80
111	38	2.69	3.90	"	7	2.00	"	9	1.90
Average		3.01							1.44

No. in tables I and II.	Days from calving.	Ave'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN MORE THAN 60 DAYS FROM CALVING.									
81	65	3.40	4.80	night.	7½	1.90	morn.	10	2.90
93	68	3.43	4.20	"	7	2.80	"	9	1.40
102	74	3.22	4.20	10 a.m.	6	2.40	4 a.m.	6	1.80
84	78	2.60	3.30	noon.	7½	2.20	morn.	10	1.10
95	78	3.35	3.60	night.	7	3.00	"	9	.60
108	64	3.45	4.40	noon.	7	2.30	"	9½	2.10
Average		3.24							1.65
Avg. all 3-yr. olds		3.22							1.48
C. Four-Year Olds. TESTS WHICH BEGAN 1 TO 15 DAYS FROM CALVING.									
118	12	3.23	3.90	night.	7	2.90	noon.	7	1.00
121	15	4.27	5.80	"	7	3.25	morn.	9½	2.55
122	6	2.91	3.30	morn.	8	2.55	noon.	8½	.75
133	14	3.05	3.80	6 p.m.	6	2.30	6 a.m.	6	1.50
134	13	3.66	4.40	noon.	7½	3.00	morn.	9½	1.40
139	10	3.02	3.60	"	8	2.30	"	8	1.30
140	10	3.52	4.50	morn.	8	2.80	night.	8	1.70
143	12	3.30	4.00	noon.	8	2.50	morn.	8	1.50
141	13	2.73	3.70	"	8	1.70	"	9	2.00
Average		3.30							1.52
TESTS WHICH BEGAN 16 TO 30 DAYS FROM CALVING.									
130	14	3.19	4.65	night.	5½	1.95	morn.	10½	2.70
131	30	2.59	3.10	noon.	7½	2.20	"	9	.90
137	18	3.24	4.90	night.	6	2.40	"	10	2.50
136	28	2.89	4.60	"	6	1.80	"	10	2.80
138	29	3.01	3.50	noon.	8	2.20	"	8	1.30
142	24	3.02	3.60	10 a.m.	6	2.40	4 p.m.	6	1.20
145	21	3.40	5.00	noon.	7	2.00	morn.	9	3.00
144	19	3.19	4.70	night.	7	2.30	"	9	2.40
Average		3.07							2.10
TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.									
115	57	3.21	4.65	night.	5½	1.95	morn.	10½	2.70
116	36	2.77	3.85	"	5½	2.00	"	10½	1.85
117	50	3.03	4.40	"	5	2.20	"	11¼	2.20
119	31	3.00	4.20	noon.	7	2.20	night.	8	2.00
120	43	2.95	4.55	"	7	1.80	"	8	2.75

No. in tables I and II.	Days from calving.	Ave'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.—*Continued.*									
124	54	3.12	3.90	night.	6½	2.50	morn.	10	1.40
126	47	3.09	4.60	"	6½	2.10	"	10	2.50
128	37	3.16	3.70	"	7½	2.70	"	8½	1.00
129	40	2.93	3.50	"	7½	2.40	"	8½	1.10
146	37	3.29	4.40	noon.	7	2.50	"	9½	1.90
147	40	3.11	4.10	"	7	2.40	night.	8	1.70
Average..3.06									1.92
TESTS WHICH BEGAN MORE THAN 60 DAYS FROM CALVING.									
113	83	3.27	4.10	noon.	8	2.40	morn.	10½	1.70
114	62	3.06	3.45	"	8	2.60	"	10½	.85
125	61	2.91	3.60	"	7½	2.20	"	10	1.40
127	104	2.85	3.60	"	7½	2.20	"	10	1.40
132	62	3.86	4.50	"	7½	2.30	"	9	2.20
135	96	3.44	4.40	"	7	2.30	"	9	2.10
123	95	3.14	3.80	"	7½	2.50	"	10	1.30
Average..3.22									1.56
Avg. all 4-yr. olds 3.13									1.76

D. Full Aged Cows.

TESTS WHICH BEGAN 1 TO 15 DAYS FROM CALVING.

152	3	2.83	4.25	night.	5½	2.00	morn.	10½	2.25
157	15	2.56	3.20	"	5	1.80	"	11¼	1.40
162	9	2.91	4 20	"	7	1.70	"	10	2.50
170	9	3.56	4.65	"	7	2.95	"	9½	1.70
173	11	2.84	4.00	"	6	1.70	"	9½	2.30
175	14	2.52	4.40	noon.	8½	1.80	"	8	2.60
176	9	2.83	3.45	"	8½	2.15	night.	7½	1.30
183	8	3.64	4.20	noon and night.	8, 7	2.80	morn.	9	1.40
204	11	2.81	3.40	noon.	8	2.40	night.	8	1.00
Average..2.94									1.83

TESTS WHICH BEGAN 16 TO 30 DAYS FROM CALVING.

160	22	3.52	4.40	noon.	7½	3.00	morn.	9	1.40
161	20	3.70	4.80	"	7	2.30	"	10	2.50
163	21	3.22	4.20	"	7½	2.60	"	9½	1.60
171	17	3.34	4.10	"	7½	2.90	"	9½	1.20
174	23	3.92	5.70	night.	6	2.40	"	9½	3.30
178	23	3.12	3.90	noon.	7	2.30	"	9½	1.60
182	18	3.44	4.30	"	7½	2.70	"	9	1.60

No. in tables I and II.	Days from calving.	Av'ge per cent fat.	High'st per cent fat.	Time of milking	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN 16 TO 30 DAYS FROM CALVING.—*Continued.*									
184	25	3.83	4.60	noon.	8	2.90	morn.	9	1.70
186	30	3.43	4.30	“	7½	2.90	“	9	1.40
185	22	3.57	4.00	“	7½	3.10	“	9	.90
188	30	3.40	4.20	night.	7	3.10	“	9½	1.10
189	30	3.16	4.10	“	7	2.50	“	9½	1.60
194	24	3.08	3.50	noon.	7	2.60	“	9	.90
198	27	3.40	4.20	“	8	2.60	“	9	1.60
201	18	3.09	3.70	10 a. m.	6	2.50	10 p. m.	6	1.20
200	20	2.91	3.70	night.	8	2.20	morn and noon.	8	1.50
Average 3.38									1.57
TESTS WHICH BEGAN 31 TO 60 DAYS FROM CALVING.									
156	33	3.26	4.60	5:15 p. m.	5	2 15	11 p. m.	5¾	3.00
158	46	3.06	4.60	“	5	2.00	4:30 a. m.	5½	3.15
159	59	2.93	3.45	noon.	7½	2.45	morn.	9	1.00
164	35	2.95	4 55	“	7	1 95	night.	8	2.60
166	53	2.79	3.65	“	7½	1.90	morn.	9½	1.75
167	42	3.23	4.70	night.	7	2.20	“	9½	2.50
168	58	3.41	4.40	“	7	2.15	“	9½	2.25
169	60	2.95	3.60	noon.	7½	2.30	“	9½	1.30
180	54	2 66	3.40	“	7½	1.90	“	10	1.50
187	31	3.11	3.90	“	6	2.60	6 a. m.	6	1.30
191	39	2.99	3.70	“	7½	1.90	morn.	9½	1.80
197	34	2.89	4.00	“	8	1 90	“	10	2.10
192	56	3.35	3.70	night.	8	3.00	night.	8	.70
195	38	3.04	4.10	noon.	7	2.30	morn.	9	1.80
196	39	3.12	3.80	night.	8	2.50	“	9	1.30
199	35	3.08	4.40	“	7	2.60	“	9	1.80
202	44	3.44	4.20	10 a. m.	6	2.90	4 p. m.	6	1.30
203	38	3.17	4.60	“	6	2.50	10 p. m.	6	2.10
205	39	3.00	4.20	noon.	8	1.80	morn.	9	1.40
207	54	3.01	3.50	night.	7½	2.40	“	9½	1.10
208	59	3.22	3.80	noon.	7	2.90	“	9½	.90
209	50	2.97	3.70	“	7	2.50	“	9	1.20
Average 3 07									1.72
TESTS WHICH BEGAN MORE THAN 60 DAYS FROM CALVING.									
148	128	3.26	4.60	noon.	8	2.40	morn.	10½	2.40
149	69	3.15	5.00	night.	5½	2.00	“	10½	3.00
150	74	2.91	4.15	noon.	8	2.15	“	10½	2 00
151	65	3.32	3.90	“	8	2.70	“	10½	1.20
153	65	3.46	4.60	night.	5½	2.00	“	10½	2.60
154	68	3.06	4.70	“	5½	1.80	“	10½	2.90
155	343	3.83	6.25	“	5	2.15	“	11¼	4.10

No. in tables I and II.	Days from calving.	Ave'ge per cent fat.	High'st per cent fat.	Time of milking.	Hours from previous milking.	Lowest per cent fat.	Time of milking.	Hours from previous milking.	Range of variation.
TESTS WHICH BEGAN MORE THAN 60 DAYS FROM CALVING.—*Continued.*									
165	82	3.20	4.20	noon.	7	2.50	morn.	9	1.70
172	140	3.29	3.75	night.	6	2.60	"	9½	1.15
177	61	2.87	3.75	noon.	8	2.35	night.	7½	1.40
179	89	3.30	3.90	"	7½	2.90	night and morn	6½, 10	1.00
181	74	3.13	3.95	night	7½	2.35	morn.	9	1.60
190	79	3.34	4.40	noon.	7½	2.70	"	9½	1.70
193	63	3.00	4.50	night.	8	2.00	night.	8	2.50
206	69	3.28	3.80	noon.	7	2.80	morn.	9½	1.00
210	65	3.22	4.10	6 a. m.	6	2.50	6 p. m.	6	1.60
Average		3.23							1.99
Avg. all old cows		3.17							1.76
Avg. all 1-15 days		3.20							1.62
Avg. all 16-30 days		3.24							1.60
Avg. all 31-60 days		3.06							1.59
Avg. all 61— days		3.20							1.60
Avg. of all tests		3.16							1.60

In arranging the data given in Table III we had in mind four questions: (1) Does the per cent of fat vary as the period of lactation advances. (By "period of lactation" is meant the time intervening between two successive calvings.) (2) Is there a variation in the per cent of fat between animals of different ages. (3) At what time of day are the highest and lowest per cents of fat found, and are they governed by the time of day or by the length of time from the previous milking? (4) What is the range of variation in per cent of fat found in different animals, and is it more at one age than another?

In order to answer the first question, the records were grouped according to age and according to the length of time from calving to the beginning of the test. Four groups were made of each age: I, of those cows whose tests began from one to fifteen days inclusive from the time they dropped their last calf; II, of those whose tests began from 16 to 30 days inclusive from that time;

III, of those whose tests began from 31 to 60 days inclusive; and IV, of those whose tests began more than 60 days from calving. It should be added that of the 47 tests which began more than 60 days from calving, all but 10, or over two-thirds, were 90 days or under.

The averages of each group are given below, together with the general averages of all ages and the average of all cows taken together.

TABLE IV.

AVERAGE PER CENTS OF FAT.

No. of group.		Two-year olds.		Three-year olds.		Four year olds.		Full aged cows.		Average of all.	
		No.	Avg. per cent.	No.	Avg. per cent.	No.	Avg. per cent.	No.	Avg. per cent.	No.	Avg. per cent.
I	Cows tested 1 to 15 days from calving...........	5	3.12	6	3.52	9	3.30	9	2.94	29	3.20
II	Cows tested 16 to 30 days from calving...........	22	3.15	12	3.30	8	3.07	16	3.38	58	3.24
III	Cows tested 31 to 60 days from calving........ ...	29	3.07	14	3.01	11	3.06	22	3.07	76	3.06
IV	Cows tested more than 60 days from calving......	18	3.15	6	3.24	7	3.22	16	3.23	47	3.20
	Average of all	74	3.12	38	3.22	35	3.13	63	3.17	210	3.16

A glance at this table will show that question 1 is not answered so far as all the cows are concerned. The smaller number tested from one to fifteen days from calving may reduce the importance of the comparison, but in all ages except two-year olds the figures can be considered fairly representative. Two-year olds gave the highest average per cent of fat in groups II and IV, three and four-year olds gave their highest average in group I, and full aged cows in group II. All except full aged cows gave the poorest milk when the test began in group III, and these find their lowest average in group I. With the exception of group III, all of the groups average practically the same for all ages. More cows were tested in group III than in any other group, which may give more weight to the figures of this group; but considering the data at hand there does not appear to be any decided increase or decrease in the per cent of fat at any time up to ninety days from calving. Beyond this time we can draw no conclusions because less than one-twentieth of all the animals were tested at a longer period from calving.

We find that there is little variation in the average per cents of fat between animals of different ages. Two-year olds average 3.12 per cent, three-year olds 3.22, four-year olds 3.13, full aged cows 3.17, and the average of all ages 3.16.

In order to answer question (3) as to the time of day at which the highest and lowest per cent of fat was found in the milk, we arranged in Table III along side of the highest and lowest per cent of fat found during the seven days, the number of hours which had elapsed between the milking at which such per cent was found and the milking just preceding. These figures may be seen in Table III in the columns marked "Hours from previous milking." Collecting together all those instances where the per cents were highest at morning, noon, and night, with the hours intervening between milkings, we have the following averages :

Time of milking.	No. of instances at which the milk was highest in fat.	Average number of hours from previous milking.
Morning	8	8.37
Noon	117	7.44
Night	74	6.59
Total and average	199	7.16

Collecting the instances of the lowest per cents of fat in the same manner, we have the following averages :

Time of milking.	No. of instances at which the milk was lowest in fat.	Average number of hours from previous milking.
Morning	165	9.47
Noon	12	7.79
Night	25	7.72
Total and average	202	9.16

In the morning the average number of hours preceding the lowest per cents of fat exceeds the number of hours preceding the highest per cents of fat by 1.1 hours. In like manner at noon the excess of hours following lowest per cents of fat over those following highest per cents of fat is .35, and at night the excess is 1.13 hours. The general averages of all the hours in each case gives an average of 7.16 hours between milkings where the highest per cents of fat were found and 9.16 where the lowest per cents of fat were found, or a difference of two hours. Accordingly, we may say that, as a rule, the highest per cent of fat follows the shortest period between milkings, and the lowest per cent of fat follows the longest period between milkings. However, looking only at the table of highest per cents of fat we see that the greatest number of highest per cents comes at noon, notwithstanding the fact that the average period from morning to noon is nearly an hour longer than the average period from noon to night. In the table of lowest per cents of fat it is to be observed that the lowest per cent occurs only one-half as many times at noon as at night, although the number of hours from each previous milking averages practically the same. Taking all these fact into consideration, it would seem that there is a tendency for the milk to average higher in fat at the noon hour than at any other time of day.

An interesting study bearing on this point is found in Table V. Twenty-two of the cows, while on test, were milked as nearly as possible at exactly equal intervals, eight at intervals of eight hours each and fourteen at intervals of six hours each, or four times daily. This table is arranged in two main divisions, one for highest per cents of fat and one for lowest, and under each division is given the time of day at which the milking was done. Then in the appropriate column, opposite each cow's number, is given the number of times during the week that she reached the highest and lowest daily per cent of fat.

TABLE V.

RICHEST AND POOREST MILK WHEN COWS WERE MILKED AT EQUAL INTERVALS.

Number in Tables I, II and III.	Highest per cent of fat. Time of milking.				Lowest per cent of fat. Time of milking.			
	5 a. m.	1 p. m.	9 p. m.		5 a. m.	1 p. m.	9 p. m.	
67	3	4	1		3	2	3	
68	2	3	1		4		2	
138		6	2		4	1	2	
139	1	4	2		3		3	
140		6			2		6	
143		6			6		1	
200		3	4		7	1		
204	1	6	2		4		3	
Total.....	7	38	12		33	4	20	
	6a. m.	12 m.	6 p m.	12 md.	6 a. m.	12 m.	6 p. m.	12 md.
44	2	1	3	4	3	2	2	
112	2	3	1	1		1	4	2
133		4	4		5			2
187	1	2	2	3	5	2	1	1
210	2	3		1			3	3
Total.....	7	13	10	9	13	5	10	8
	4 a. m.	10 a. m.	4 p. m.	10 p. m.	4 a. m.	10 a. m.	4 p. m.	10 p. m.
60		5		1	2	1	2	1
61	1	4		2	2		3	2
100	2	1	1	3	3	2	3	
101		3		4	3		3	
102		4	2		4			3
144	1	5					6	
201	2	3		1	2		2	3
202		5		1	3		3	2
203		3	3	2	4		1	1
Total.....	6	33	6	14	23	3	23	12
Total of all which were milked four times daily	13	46	16	23	36	8	33	20

Among the eight cows which were milked at three equal intervals it will be seen that, of all the instances where the milk reached its highest daily per cent of fat, 38, or two-thirds, came at the middle of the day, while of the 57 instances of lowest daily per cent, 33,or over one-half, came at the morning milking.

In considering those cows which were milked four times daily, it will be practically correct to count the four and six o'clock milkings together, and the other milkings in the same order as arranged in the table. Then for the complete summary we have 98 instances where the milk reached its highest daily per cent of fat, of which 46, or nearly one-half, occur at the noon hour, and twice as many as at any other time. In the lowest per cents of fat there is very little difference between the number of instances at morning and afternoon milkings.

These figures then, bear out the statement made above, that the milk drawn at noon has a tendency to average higher in per cent of fat than the milk drawn at other times during the day, and this seems to be true whether the milking be at equal or unequal intervals. The lowest per cents of fat, however, do not so invariably occur at the morning milkings as when the cows are milked at unequal intervals with the longest period invariably between night and morning. When the milkings are at equal intervals the honors are divided between morning and night, especially if there be four milkings daily. It would be of interest to know the causes of all these variations, but at present we are more or less in the dark in regard to them. May it not be that the higher per cent of fat at noon is partly the result of the warmer and more even temperature surrounding the animal?

As to the range of variation in the per cent of fat during the week found in different animals, the following summary from Table III will give some indication.

Age.	Greatest Variation.	Least Variation.	Average Variation
Two-year olds	3.60	.40	1.42
Three-year olds	3.20	.60	1.48
Four-year olds	3.00	.75	1.76
Full-aged cows	4.10	.70	1.76
Average of all cows			1.60

The greatest average variation is found among those animals which we would naturally suppose to be most constant in their per cent of fat, namely, the older cows. The average variation for four-year olds and full-aged cows is exactly the same. The average variation for two and three-year olds is practically the same, and about three-tenths of one per cent lower than among the older cows.

If the variation in per cent of fat be averaged according to the groups given in Table IV, a striking similarity is found between the averages for the different groups as can be seen from the figures here given.

No. of Group.		Average Variation.
I.	Cows tested 1 to 15 days from calving	1.62
II.	" " 16 to 30 " " "	1.60
III.	" " 31 to 60 " " "	1.59
IV.	" " more than 60 days from calving	1.60
	Average of all	1.60

In the table below are given two instances under each age of individual variation in per cent of fat,—one for the greatest and one for the least variation. Along side of the greatest variation for the week is given the greatest variation for one day and also the pounds of milk and per cent of fat for each milking on that day, together with the total fat for the day. There is also given the same data for the day on which the least variation in the per cent of fat occurred, and finally the total fat for the week. Moreover, in order to compare these animals showing so great and so little variation with animals of the same class, there is also given under each age the largest, smallest and average weekly yield of fat for that age.

TABLE VI.—INDIVIDUAL VARIATION IN PER CENT OF FAT.

Number in Table I.	Age.	Greatest and least variation in per cent of fat.		Pounds of milk and per cents of fat given at the three milkings on that day.						Total pounds of fat.	
				Morning.		Noon.		Night.			
		For the we'k	For one day.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	For the day.	For the week.
70	2	3.60	3.40	14.625	2.0	15.250	5.4	12.000	3.6	1.549	
			.10	13.000	2.4	14.000	2.5	16.625	2.4	1.061	9.695
14	2	.40	.30	17.625	3.1	12.000	2.9	13.250	2.8	1.265	
			.10	16.000	3.0	12.375	2.95	12.125	2.9	1.197	8.289
Largest weekly yield of fat for two-year olds											12.675
Smallest " " " "											5.263
Average " " " "											8.697
99	3	3.20	3.20	19.000	2.0	18.500	4.0	15.500	5.2	1.926	
			1.10	20.688	3.1	18.125	4.2	15.375	3.8	1.986	12.978
106	3	.60	.40	18.938	2.9	14.250	3.3	16.375	3.1	1.527	
			.10	19.000	3.3	14.125	3.3	16.125	3.2	1.609	10.824
Largest weekly yield of fat for three-year olds											17.472
Smallest " " " "											7.665
Average " " " "											11.555
145	4	3.00	2.50	19.500	2.2	17.250	4.7	17.000	3.5	1.835	
			.10	18.375	3.5	15.750	3.5	16.625	3.4	1.759	13.069
122	4	.75	.50	21.375	2.65	22.000	2.65	19.750	3.15	1.771	
			.20	21.688	2.95	21.188	3.00	22.313	2.80	1.901	12.713
Largest weekly yield of fat four-year olds											18.265
Smallest " " " "											7.100
Average " " " "											13.091
155	6	4.10	2.95	10.688	2.15	14.188	5.10	5.000	4.60	1.184	
			1.65	16.125	2.80	14.063	4.45	5.563	4.25	1.314	8.761
192	11	.70	.60	24.875	3.10	20.000	3.50	21.000	3.70	2.248	
			.20	24.750	3.40	20.500	3.50	21.000	3.30	2.253	15.459
Largest weekly yield of fat for full aged cows											21.333
Smallest " " " "											8.761
Average " " " "											14.106

Here it will be noticed that among the examples of largest variation each animal, except the full aged cow, No. 155, gave more fat than the average for her class. Those with the least variation are only a little lower than the average in total fat except the full aged cow, No. 192, which is quite above the average. Thus it is evident that neither those animals which vary much in per cent of fat nor those which vary little can be termed abnormal animals, and that a cow can give a good yield of fat if her per cent does or does not fluctuate widely.

TABLE VII.

RECORDS OF COWS WHICH HAVE BEEN TESTED MORE THAN ONCE.

Name of Cows.	No. in tables I and II.	Age at calving. yr.mo.da	Days from calving.	Pounds of milk.	Average per cent fat.	Pounds of fat	per cent of gain or loss.	Per ct. incr'se requir-ed on equivalent record.
Inka Pietertje Mechthilde	2	2- 0-27	36	282.250	3.08	8.696		
	78	2-11-23	11	349.125	3.25	11.348	+30.5	19.8
	199	5-10 29	35	409.938	3.08	12.614	+11.2	36.9
DeKol 2d's Pauline	4	2- 0- 4	63	245.000	3.72	9.116		
	80	3- 1-26	12	338.250	3.45	11.676	+28.1	25.3
Sadie Vale Concordia	8	1-11-25	28	317.625	3.50	11.116		
	11	1-11-25	53	295.250	3.30	9.756		
	82	3- 3-29	56	414.500	3.50	14.485	+30.3	30.5
	134	4- 6- 3	13	494.250	3.66	18.103	+24.9	20.1
	*201	5- 5- 3	18	542.313	3.09	16.772		
America 2d's Pauline Paul	9	1-11-26	24	247.000	2.80	6.906		
	10	1-11-26	49	236.438	2.87	6.780	— 1.8	
Clothilde Artis Belle	18	2- 0-29	61	273.750	3.40	9.372		
	133	4- 1-10	14	466.750	3.05	14.272	+54.4	44.3
Pauline Paul Grant	20	2- 1- 4	68	354.188	2.96	10.487		
	86	3- 7- 4	47	417.500	2.90	12.116	+15.5	32.6
Princess of Wayne 7th's Pauline	22	2- 1-11	22	242.500	3.75	9.082		
	85	3- 4- 8	18	327.000	3.61	11.824	+30.2	26.9
Princess Aaggie's Pauline DeKol	23	2- 0-29	21	243.125	3.24	7.879		
	87	3- 2-22	51	343.000	3.02	10.378	+31.7	25.0
	142	4- 2-24	24	478.375	3.02	14.461	+39.2	17.4
Prairie Flower's Pauline Paul 2d	25	1-10- 8	20	321.500	3.17	10.184		
	92	3- 4-21	45	310.625	2.85	8.846	—13.1	34.1
Mutual Friend's Pauline DeKol	26	2- 1-22	51	239.625	3.56	8.538		
	93	3- 8-12	68	344.125	3.43	11.816	+37.2	34.8
Pauline Paul America 2d	27	2- 1-13	57	263.250	3.37	8.860		
	94	3- 8-24	55	345.500	3.18	11.094	+25.2	34.9
Inka 8th	29	1-11- 7	47	242.500	3.15	7.649		
	145	4- 0- 3	21	383.500	3.40	13.069	+70.9	46.0
Clothilde Artis Topsy	37	1-11-24	86	298.250	3.01	8.970		
	88	3- 1- 8	30	441.250	3.21	14.176	+58.0	24.9
	*146	4- 1-10	37	415.750	3.29	13.724		

*Economic food test.

Name of cow.	No. in tables I and II.	Ages at calving. yr. mo. da	Days from calving.	Pounds of milk.	Average per cent fat.	Pounds of fat.	Per cent of gain or loss.	Per ct. incr'se required on equivalent. record.
America 2d's Pauline DeKol	38	2- 1-29	21	334.375	2.79	9.339		
	*39	2- 1-29	105	305.188	3.32	10.043	+ 7.5	
	101	3- 5-15	27	520.188	3.06	15.903	+58.3	27.7
Paul DeKol's Mutual Friend	40	2- 0-15	72	242.125	3.50	8.500		
	100	3- 3-29	27	375.938	3.18	11.955	+40.6	28.3
Patty Waldorf	43	2- 1-22	90	244.000	3.12	7.616		
	98	3- 3-18	17	364.188	2.97	10.810	+41.9	24.9
Clothilde Artis Aaggie Bright	47	2- 0-23	34	256.813	3.47	8.896		
	105	3- 1-22	14	325.313	3.96	12.875	+44.7	23.6
Clothilde Artis Aaggie Lass	48	2- 0-21	26	258.188	3.21	8.298		
	106	3- 1- 1	25	339.313	3.19	10.824	+30.4	22.5
Clothilde Artis Constance	49	2- 0- 3	46	275.875	3.05	8.424		
	107	3- 0-20	38	367.188	3.11	11.423	+35.6	23.2
Clothilde Lunde Artis	50	2- 0- 7	15	281.750	3.34	9.404		
	108	2-10-28	64	371.625	3.45	12.821	+36.3	19.7
Hetje 6th's Pietertje	51	2- 2-10	6	251.750	3.48	8.783		
	103	3- 0-29	41	384.313	2.89	11.123	+26.6	18.8
AaggieGrace Clothilde	55	2- 0- 9	107	280.438	3.17	8.890		
	109	3- 3-16	20	462.375	3.20	14.796	+66.5	28.2
Mutual Friend 3d	76	3- 2-24	17	409 188	4.27	17.472		
	77	3- 2-24	42	355.438	3.59	12.738	—27.1	
	121	4- 3- 8	15	427.938	4.27	18.265	+ 4.5	18.1
	184	5- 6-15	25	431.938	3.83	16.327	—10.6	10.7
	*190	5- 6-15	79	363.875	3.34	12.184		
	*202	6- 6-26	44	427.438	3.44	14.724		
Pauline Paul Georgie.	79	3- 4-20	15	344.875	3.30	11 406		
	128	4- 4-15	37	437.625	3.16	13.808	+21.1	16.7
	188	5- 3-20	30	376.125	3.40	12.819	— 7.2	13.1
Helena Burke	115	4- 3-10	57	418.000	3.21	13.416		
	162	5- 3- 0	9	518.250	2.91	15.089	+22.5	10.6
	187	7- 3-10	31	654.125	3.11	20.364	+51.8	10.6
Magadora	119	4- 1- 6	31	353.625	3.00	10.696		
	173	5- 1-20	11	444.500	2.84	12.605	+17.8	11.1
Debora's Inka	125	4- 5- 0	61	521.250	2.91	15.188		
	194	5- 5-23	24	509.000	3.08	15.667	+ 3.2	8.4

*Economic food test.

Name of cow.	No. in tables I and II.	Age at calving. yr.mo.da	Days from calving.	Pounds of milk.	Average per cent fat.	Pounds of fat.	Per cent of gain or loss.	Per ct. incr'se requir-ed on equivalent record.
Princess of Wayne 7th	129	4- 3-20	40	459.625	2.93	13.450		
	189	5- 2-29	30	463.625	3.16	14.680	+ 9.1	10.2
	203	6- 1-27	38	491.438	3.17	15.600	+15.9	10.2
Hartog Pieterje Netherland	132	4-10-13	62	415.688	3.86	16.258		
	*135	4-10-13	96	403.750	3.44	13.819		
Netherland Hengerveld	151	5-10- 3	65	410.250	3.32	13.627		
	174	7-11- 7	23	544.875	3.92	21.333	+56.5	
Inka Hartog	152	7- 1-16	3	383.125	2.83	10.960		
	164	8- 0-16	35	494.125	2.95	14.573	+33.0	
Netherland Wayne	159	5-10-16	59	436.000	2.93	12.767		
	166	6-11- 4	53	446.438	2.79	12.470	— 2.3	
MutualFriend 2d	160	7- 0-17	22	585.125	3.52	20.608		
	182	9- 1- 3	18	589.250	3.44	20.242	— 1.8	
Plum 4th	161	6- 0- 5	20	419.000	3.70	15.519		
	165	6- 0- 5	82	465.250	3.20	14.837	— 4.4	
Aaggie 3d's Wayne	163	7- 4- 5	21	487.063	3.22	15.705		
	171	8- 3- 5	17	497.063	3.34	16.582	+ 5.6	
	*183	9- 2-12	8	410.000	3.64	14.773		
Aaggie Grace 2d's Pietertje	177	5- 2- 0	61	624.938	2.87	17.906		
	197	6- 2-23	34	651.750	2.89	18.803	+ 5.0	
Patty's Pet	179	9-11-13	89	380.125	3.30	12.562		
	185	11-0- 2	22	453.500	3.57	16.203	+28.9	
	*192	11-0- 2	56	460.875	3.35	15.459		
Sadie Vale 2d	181	7- 2-25	74	322.813	3.13	10.099		
	198	8- 3-14	27	340.250	3.40	11.656	+15.4	
Janie Hijlaard's Inka	186	5- 0-26	30	446.063	3.43	15.320		
	193	5- 0 26	63	451.125	3.00	13.536	—11.6	
Aaggie Grace's Boy's Topsy	191	7- 0-17	39	448.375	2.99	13.410		
	207	8- 0-13	54	458.250	3.01	13.800	+ 2.9	
Vrouwkje of Hijlaard 7th	195	6- 1- 4	38	441.625	3.04	13.427		
	205	7- 0-26	39	492.250	3.00	14.791	+10.1	
Average of 2 to 3 year olds							+34.4	26.4
Average of 3 to 4 year olds							+21.7	19.0
Average of 4 to 5 year olds							+12.0	11.3
Average of all cows exclusive of those which were tested twice in the same period of lactation or not tested until they had reached full age							+26.6	21.4

*Economic food test.

Table VII places in ready comparison the records of those cows which have been tested more than once. Nine were tested twice during the same period of lactation and all of these gave a less amount of fat on the second test than on the first except No. 39. In this case she gave less milk than at the first test, but her per cent of fat was greater by .53 of 1 per cent, so that the total fat was also greater. (She was in an "Economic Food Test" the second time.) Three gave more milk and two a higher per cent of fat on the second test than on the first. The average production of the nine on their first tests is,—386.042 pounds of milk, 3.53 per cent fat and 13.829 pounds of fat. Their average on the second tests is,—381.91 pounds of milk, 3.27 per cent fat and 12.128 pounds of fat. Accordingly, we may infer that, as a rule, a cow which has been forced to her utmost for seven days cannot again be made to reach the same point either in production of milk or fat during the same period of lactation.

"EQUIVALENT RECORDS."

According to the scheme adopted by the Holstein-Friesian Association for the admission of cattle into the Advanced Registry, each two-year old must have produced 7.2 pounds of fat, three-year old 8.8, four-year old 10.4, and each cow, five years old or older, 12 pounds of butter-fat in seven days. It is considered by the Association that a two-year old which produced 7.2 pounds, a three-year old which produced 8.8 pounds, or a four-year old which produced 10.4 pounds of fat would, when she reached the age of five or over, produce 12 pounds. Or, in other words, a yield of 7.2 pounds of fat by a two-year old, 8.8 by a three-year old, or 10.4 by a four-year old is equivalent to 12 pounds when the heifer reaches full age. To make this plan good there must be a gain of 1.6 pounds of fat during each succeeding year, which requires an average gain of .13⅓ pounds per month and .00438 pounds per day. In other words, the gain from two to three years must be 22.2 per cent, from three to four years 18.2 per cent, and from four to five years, 15.4 per cent.

In Table VII in the column headed "Per cent of Gain or Loss" is given the actual gain or loss per cent sustained by the cow from one test to another. In the column headed "Per cent of

Increase required on Equivalent Record" is given the per cent of increase the cow ought to make for the same length of time in order to make good her equivalent record. For the basis of determining what the per cent of gain on the equivalent record should be, there is taken the amount of fat the cow should produce during the time which elapsed between two successive calvings; this amount is divided by the amount of fat a cow of her age should produce at the time of the first of these two calvings; for example, No. 2 was 2 years and 27 days old at the time she dropped her first calf, and at such age should produce 7.318 pounds of fat. The time intervening between the first and second calf was ten months and 26 days, and she should gain in this time in production of fat 1.447 pounds. This would make a gain over 7.318 pounds of 19.8 per cent, which is her required gain on the basis of equivalent records. Her actual gain was 30.5 per cent, so that she did much better than her requirement. On the other hand, this same cow from the ages of three to five actually gained 11.2 while her required gain was 36.9 per cent. In working out equivalent records no account is taken of age over five years.

In the same manner the actual and equivalent gains are made out for those cows in Table VII which were tested at the various ages from two to five and the averages under each head and for each age are given. From these averages it will be seen that among the different ages, three, four and five-year olds, the actual gains were in excess of the gains required on the basis of equivalent records.

The actual gains from year to year as determined from the average records of all the cows, and the average gains required on equivalent records present such a wide variation from each other and from the figures determined in Table VII, that we have placed all the averages in tabular form below for ready comparison.

	From 2 to 3 years. Per cent.	From 3 to 4 years. Per cent.	From 4 to 5 years. Per cent.
Actual gain as found from average product for all cows of different ages (Table I)	32.7	13.3	7.7
Average gain required on equivalent record plan.	22.2	18.2	15.4
Actual gain as found from average gains of cows that were tested more than once	34.4	21.7	12.0

From the averages found in Table I it would seem that, as a rule, the cow has nearly reached her full capacity for production at the age of four years and that she does not gain as much in the remaining year as is required by the equivalent record system. On the other hand, a study of the cases given in Table VII shows this system to be fairly accurate. It is without question that the cows which have been tested several times are above the average in power of production and for this reason they may be more able to keep up the pace set for them than are the average cows.

GENERAL SUMMARY AND CONCLUSIONS.

The largest total yield of fat among two, three, four-year old, or full aged cows, is, under every age, accompanied by the highest per cent of fat found among cows of that age.

The smallest yield of fat for each age of animal is accompanied in only one case by the lowest per cent of fat, and that among the two-year olds.

The largest yields of milk do not contain the lowest per cents of fat nor do the smallest yields of milk contain the highest per cents of fat.

The stall fed cows average higher in total yield of milk and fat and in per cent of fat than the cows at pasture.

Equal quantities of the same kinds of food or similar quantities of different kinds of food produce widely varying amounts of milk and butter in different animals.

To produce the same or similar amounts of milk and butter different animals require widely varying amounts of food.

Cows, although of the same breed and raised in the same herd, vary greatly in their power to make an economic use of food.

The cost of production is greatest among two-year olds and decreases gradually as the age increases up to four years, after which there is little if any variation.

Within a period of ninety days from calving there is but little average variation in the per cent of fat among the different ages, except that the average of all the tests made at thirty-one to sixty days from calving is lower than for any other period.

There is slight variation in the average per cent of fat between two, three and four-year olds, and full aged cows.

The highest per cents of fat usually follow the shortest period between milkings. The lowest per cents of fat usually follow the longest period between milkings. Where the cows are milked at equal intervals the highest per cent occurs most often at or near the noon hour, and the lowest per cent about equally often at morning and night with a much larger number at midnight than at noon.

The average range of variation during seven days between the highest and lowest per cents of fat for individnal animals is greater among four-year olds and full aged cows than among the younger animals.

Neither the cows which show very great variation during seven days in the per cent of fat nor those which show slight variation are abnormal animals, since their total product of milk and fat is near the average for their class.

Cows which have been once tested and forced to their greatest capacity for a week rarely reach the same height of production again during the same period of lactation, even though the circumstances be otherwise most favorable, but frequently have made increased records in succeeding periods of lactation.

There is an increase of only 7.5 per cent of milk and 7.7 per cent in fat of full aged cows over four-year olds, which shows that, on an average, cows have very nearly reached their largest production between the ages of four and five.

The "Equivalent Record" plan is supported by the records of individual cows which have been tested at various times from two to five years of age, but not by the average records of all the cows of the different ages.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
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75 Peach Yellows, 20 pp.
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144. Suggestions on Spraying and on the San José Scale.
145. Some Important Pear Diseases.
146. Fourth Report of Progress on Extension Work.
147. Fourth Report upon Chrysanthemums.
148. The Quince Curculio.
149. Some Spraying Mixtures.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1898.

150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.
152. Studies in Milk Secretion.

Bulletin 153. **October, 1898.**

Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

HORTICULTURAL DIVISION.

IMPRESSIONS OF OUR
FRUIT-GROWING INDUSTRIES

By L. H. BAILEY.

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CORNELL UNIVERSITY, ITHACA, N. Y., Oct. 21st, 1898.

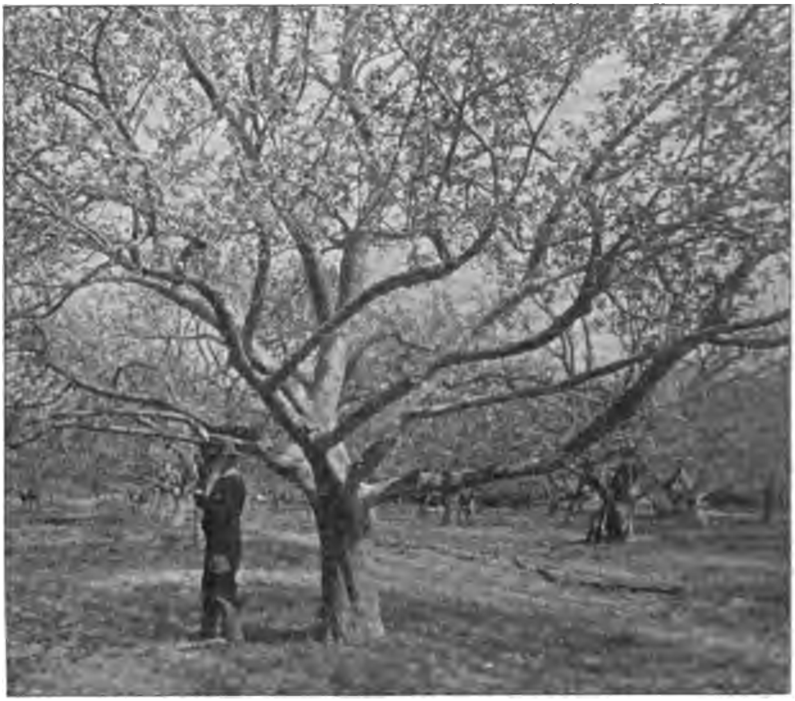
THE HONORABLE COMMISSIONER OF AGRICULTURE,
ALBANY, N. Y.

Sir: This bulletin is submitted for publication under Chapter 67 of the Laws of 1898.

Five years ago Professor L. H. Bailey began to make a careful study of the fruit-growing industry. Since that time he has visited Florida and other southern states and has made himself familiar with the production of many classes of fruits. He has studied the problems under consideration not only in all of the fruit-growing counties of this state, but has made trips into the fruit-growing districts of Europe.

While this bulletin does not embody the results of strictly scientific investigations, it does give, in a concise form, the conclusions reached by the author after a long, careful study of fruit-growing under widely different climates, soils, markets and local conditions. Few Americans have had the opportunity for making such extended observations and few writers on fruit-growing have shown a greater interest in the welfare of both producer and consumer. It is therefore with pleasure that I submit this bulletin which embodies the ripened judgment of an expert.

I. P. ROBERTS,
Director.



7.—Clean tillage in a New York orchard. It is commonly said that plantations in which the trees are trained so low cannot be well tilled. For a discussion of means of tilling orchards, see our Bulletin 72.

IMPRESSIONS OF OUR FRUIT-GROWING INDUSTRIES.

Some years ago, the writer was asked to undertake an investigation, on behalf of the State, of the fruit-growing of New York. An attempt was made to determine the extent and condition of the industry, to discover the leading difficulties, to devise means to combat insects and fungi, and, by means of lectures and publications, to give advice to fruit-growers. As a result of the inquiries, there have appeared, by various persons, 34 bulletins, covering most of the fruits which are commercially grown in the State. In the progress of these investigations, it became apparent that there are greater problems in our fruit-growing than those of soil and insects and diseases, that fruit-growing is profitable or not, in the long run, in proportion as it meets the general requirements of trade and conforms to the agricultural status of the time. It became apparent, also, that even the immediate problems of fertilizers, tillage, and handling of a plantation cannot be fully understood from mere scientific investigations at a given place. The investigator must correlate and compare the results of actual fruit-growing in many places and under many conditions to be sure that he arrives at broad and sound conclusions, or at principles. With this thought in mind, an effort has been made, in the last five years, to determine the underlying reasons for some of the successes and failures of the fruit-grower, by studying the actual experiences of fruit-raisers; and some of the summary conclusions of this inquiry are given herewith. Such conclusions are necessarily colored by the personality of an author, and the writer must therefore say that they are meant to be expressions of general truths rather than statements of specific facts, and that he cares less whether they are accepted by the reader than that they shall suggest his thinking out his problems for himself.

I. AMERICA IS A LAND OF FRUITS.

The fruit-growing interests of the United States are very large and are rapidly expanding. Of some fruits we are already raising more than we consume, and we therefore find a market abroad; and if we are to compete in foreign markets, we should know something of the conditions under which the fruits of our competitors are grown. In other words, it is important that we understand why America is a land of fruits.

1. America is a land of fruits because, for one thing, its agriculture is so recent and so little bound by tradition, that the farmer feels himself free to discard old and unprofitable enterprises for new and relatively profitable ones.

In the unrest which has come from agricultural depression, the newer and less-worked business of fruit-growing asserts itself over the old-time agriculture. It does not follow, however, that fruit-growing will continue to be the more lucrative business. In fact, it is possible that it may come to be overcrowded. But its rise has relieved the over-worked old-line farming, and, as a whole, has been a blessing both to those who went into it and to those who remained out of it; and it has exerted a most important secondary influence in diffusing new knowledge and thereby in educating the people.

2. Again, North America is the leading fruit-growing country of the world because large areas are available for the business.

Fruits are grown on a large base, and in wholesale quantities. This means that they are grown cheaply and that the product is of sufficient quantity and uniformity to attract the attention of the market. This is illustrated in a smaller way by comparing the two sides of the continent: Californian fruit is often able to drive the eastern fruits from their own markets because it is in larger and more uniform supply and thereby controls the market. It is the large base upon which American fruit-growing is established which enables it to enter European markets.

3. Political and social conditions are essentially uniform in all parts of the country, allowing of a free interchange and comparison of ideals and methods.

In Europe, the various fruit-growing centers are apt to be unique. The business is the outgrowth of years and centuries of local effort and tradition. There are difficulties or barriers of races, languages, political systems, and physiographies. Uniformity of methods and results on a large base is practically impossible. In North America, we speak one language and live in practically one political and social environment. We can therefore have community of ideals. We grow thousands of acres of one variety, if need be, and growers work towards a common end.

4. The climate of North America is congenial to fruits.

5. The American farmer has more help from teachers and experimenters than other farmers have.

A fundamental idea of our agricultural colleges and experiment stations is to reach the very man who tills the soil. The teacher and the farmer are in most intimate contact. As a consequence, the fruit-grower quickly assimilates new methods. He is not fettered by tradition. He is bold and confident. He feels that he controls his own efforts and destinies. He receives help at every doubtful point. The result of all this is that the general tone of agricultural business is rising, and the farmer is feeling more and more independent because he knows that he can receive aid and advice in his perplexities. Even those persons who depreciate the colleges and stations, are nevertheless greatly dependent upon them, for they share the general mental uplift and partake of the new ideas which diffuse from the teacher and the experimenter into every farmer's meeting, into the schools, and the rural press. Public sentiment is compelling better farming.

As a consequence, knowledge of all theories and practices which make for better fruit-growing are being rapidly popularized. It is enough to cite only a single example,—the fact that spraying for the control of insects and diseases is better understood and more extensively practiced by the fruit-growers of America than by those of any other country.

II. PROBLEMS OF MARKETING MUST RECEIVE GREATER ATTENTION.

It is generally the first thought of the fruit-grower to plant that kind of fruit which he can raise. It is quite as important, however, to plant that which he can sell. It is the business of the experiment station to determine means of increasing the production; it does not teach means of selling the product except as it makes the product better. There is necessity, therefore, that problems of marketing receive more and more attention from farmers; and these problems are more complex with the increase of population and of competition.

The first step in a discussion of marketing is a classification of the purposes of the given enterprise. Classified in respect to the objects in view, there are two kinds of fruit-growing,—that which desires the product primarily for home use, and that which desires it primarily for market. Of market or commercial fruit-growing, there are again two types,—that which aims at a special or personal market, and that which aims at the general or open market. The ideals in these two types of fruit-growing are very unlike, and the methods and the varieties which succeed for the one may not succeed for the other.

The man who grows fruits for the special market, has a definite problem. The product is desired for its intrinsic qualities; and special products demand special prices. The man who grows fruit for the world's market, has no personal customer. The product is desired for its extrinsic or market qualities; and the world's products bring the world's prices. The special-market fruit-grower generally works on a small base. The world's-market fruit-grower works on a large base; or he sells to another who, by combining similar products of many persons, is able to command the attention of the market. Failure to distinguish these two categories is the result of a confusion of ideas. One grows fruit either for a special and personal market, in which case he looks for his own customer and is independent of general trade; or he grows what the market demands, and allows the machinery of trade to handle the product. In the latter effort, the American fruit-grower is preëminent ; but in the former he has made little more than a beginning.

1. The essence of these remarks is the fact that in the staple or large-area crops, the demand regulates the supply ; whereas, in products which are essentially luxuries, amenities and accessories, the supply largely regulates the demand.

The world's staples are breadstuffs, meats and materials for clothing and building ; but in fruits there are some types or varieties which are staples for that group,—staples in the sense that they are adapted to cultivation over wide areas and to be sold in the general and open markets. In apples, the Baldwin and Ben Davis are staples ; Chenango and Lady are accessories.

2. It follows, then, that general or staple products find their best outlet in the general and open markets ; special and accessory products find their only outlet in particular and personal markets.

This law is well illustrated in the market for glass-house products. Persons are always wondering that there should be sale for forced tomatoes and strawberries after the southern-grown products are in the market ; but the fact is that one does not compete with the other. The accident that the products from the glass-house and from Florida are called by the same name does not signify that they are purchased by the same parties. There is a market for glass-house produce and a market for field-grown produce ; if the glass-house produce is offered in the other market, the prices are not sufficient to pay the cost. Shall I grow apples on free stocks or on dwarfs ? Whichever you like ; but with the dwarf-grown fruit you cannot compete in the open market. You cannot afford to sell dwarf-grown apples in barrels : such apples cost too much to raise. You cannot afford to grow Baldwin or Ben Davis on dwarfs, for apples thus grown cannot compete with large-tree orchards ; and the gain in quality (due to the better care) of such low-quality varieties when grown on dwarfs, costs more than it is worth. The dessert apples can be profitably grown, perhaps, on dwarfs, provided they are put into a dessert market. The staples may be sold to the itinerent buyer, but the special products must be handled by the producer or his agent. How often we grow the fruit, but miss the market!

These facts respecting the two classes of products and markets are, it seems to me, the most imperative lessons for the American fruit-grower now to learn.

3. The foreign market may be expected to increase.

I have already outlined the reasons, as they appeal to me, for the great development of fruit-growing in North America; and therein are stated reasons why we can enter the European markets. It only remains to add that the European consumers desire our fruit. It is handsome, uniform, and much of it is of excellent quality. It is also well packed; or, rather, that which is not well packed does not reach the discriminating consumer. The English are now well acquainted with our apples, and fruit-buyers on the continent, particularly in Germany, are learning to know them. The foreign market is only fairly opened: it is not yet supplied. Most persons with whom I have talked in Europe believe that the European fruit-growers cannot compete with the American in general-market fruit and they are looking for a growing trade in American produce; and my own opinion is that they cannot compete with us in apples, and probably not even in pears and some other fruits. But as exportation increases the more discriminating the foreign market will become. Greater and greater attention must be given to packing and grading, selection of varieties, and particularly to good tillage, thinning and spraying; for spraying gives a better keeping as well as a sounder fruit.

A person connected with an experiment station is often asked if he would advise the planting of more fruit. The question is one which pertains to business and is therefore not within the purview of the experimenter; and the success of any venture is intimately associated with the personality of its promoter. Yet, one can form some notion as to whether fruit-growing is overdone, or whether there is still opportunity for expansion. Now, every business is overdone in its common levels. There is competition everywhere. The success of a business, therefore, depends more upon the man than upon the business. The first advice, therefore, is to choose the business which one likes best.

Again, one must not expect a financial success every year. There are good and bad years in fruit-growing, as there are in manufacturing or store-keeping. The fruit-grower should go into the business, therefore, as a long-time or more or less permanent undertaking, expecting to become more adept each year. He should then distinguish the type of market for which he desires to grow. If he is to compete in the general open markets he must work on a comparatively large base. The man who has only a small area will generally do best in the growing of special things—if he have sufficient skill—for personal markets. As a people, we are not diverse enough in our fruit-growing. Too many of us are aiming at the general, common market,—assuming that we aim at all. It seems to me that the success in the general metropolitan and export markets is to be more and more secured by large-area fruit-farming, and that other fruit-farmers must develop sufficient skill to raise choicer things for more restricted and better markets. As a whole, fruit-growing is not overdone, particularly if the foreign markets are properly encouraged and supplied; but in particular places and cases it is overdone. Some fruits are not capable of indefinite extension. It seems, for example, that grape-growing in western New York has reached the limit of its profitable development for the time being. Grapes are a dessert fruit. They are not used to a large extent in culinary preparations; and there are few incidental or secondary products,—that is, they are not dried, canned, made into jellies, and the like, to any extent. Moreover, quality in a grape does not show on the surface as it does on apples or peaches. In apples, there is likely to continue to be demand for export, and the demand for dessert apples is almost wholly unsupplied. In fact, the demand of the world's markets has obscured the importance of the special markets. Of good peaches, pears, apricots and berry fruits there is sufficient supply only in occasional years; for even when the open market may be full, there are still persons who are asking for a better grade for private use. All these hints are given to indicate the fact that success in fruit-growing is quite as much the hunting out of a market as the raising of the fruit; and the market problem should be clearly in mind from the moment the plantation is planned.

III. THE HANDLING OF THE PLANTATION.

The details of the handling of the fruit plantation are discussed in many bulletins issued from this and other stations; but there are some general considerations—or ways of looking at certain questions—which it may be profitable to discuss.

Sod or tillage.—This an old question, this controversy whether sod or tillage is better for an orchard. Plantations will be cited to prove either case, which really prove them both. That is, for the orchard which does better in sod, sod is the better. But it cannot be that both are equally good; and if not, then we should discover which is fundamentally better, and the other will thereby be the exception which proves the rule. Now, there have been bulletins and expositions enough to show that liberal tillage is the better condition for the orchard; and the man who cites his plantation as an example of a contrary fact, cites only an isolated case and one which should be explained. He does not cite a principle. It is desirable that horses be shod; yet there are circumstances in which it is better that they be barefoot. I shall not repeat arguments for tillage, but give a few summary conclusions of observations.

European large-area orchards are generally in sod; and this fact is perhaps one reason for the prevalence of sod orchards in America, since European practice becomes known in this country through books and foreign-born farmers. There are various reasons for this condition which, it seems to me, will not apply here. In the first place, the country is moist and there is less necessity for conserving moisture than in America. The drier the country, the better is the tillage, other things being the same. Compare the frequency of sod orchards in New England with their infrequency in California. Again, the higher price of land and the smaller farms, make it necessary to support two crops on the same land,—trees and grass. In parts of Europe which are primarily grazing or dairy regions, the tree fruits are in reality a secondary or catch crop, as, for example, in the cider-producing parts of Normandy. In other parts, cattle are kept indoors most of the summer and are fed newly-cut grass; this grass may be gleaned in orchards. Still again, the large-field plantations of fruit-trees in Europe are generally of secondary importance to the small-area or garden plantations. In the fruit-gardens, the trees are excellently well trained, fertilized and tilled, and the results are usually good. Yet again, there is less horse-labor and fewer horse-tools in Europe than in this country. And finally, many of the plantations are rented, and the lease-holder has little interest in such long-time investments as fruit-trees.

It is undeniable that excellent results are often secured in sod orchards, but the reasons for these good results must be determined for each case. By examining such cases under a wide range of conditions, however, one may be able to formulate a a few general statements or principles. We may first throw out of our inquiry those cases in which the sod is present merely because the owner has neglected to till. He has not had time to care for the orchard as he cares for the other parts of the farm. In most of these cases, the orchard is a mere incident to a general scheme of grain-farming or dairying. The land is needed for pasturage, and if fruit is obtained it is clear gain. This is a perfectly legitimate practice. The owner has no taste for fruit-growing and does not expect to compete with fruit-growers. He is in other business; and it is doubtful if it would pay him to reduce his grazing area and neglect other affairs by keeping the orchard in a high state of cultivation.

There now remain those cases in which the farmer believes that orchards do better in sod than in clean tillage. My own opinion is, from an examination of hundreds of these instances, that the greater part of such orchards thrive in spite of the sod, not because of it. It is very rare that the farmer has made comparisons of the two methods side by side. If he has made any comparative observations, they have been drawn between his plantation and his neighbor's; but the two are often not comparable, being on different sites, soils, and of different varieties. Because an orchard does well in sod, does not prove that it might not do better in tillage.

There are many instances in which the orchardist has tried tillage and has found it to be unsatisfactory. In the greater number of such cases, the tillage was begun too late in the life of the plantation to yield good results: the habit of the trees had already been established and the shallow root-systems had been formed.

In another class of cases, the grower is misled by an occasional very heavy crop into the belief that his orchard is successful. It is the habit of sod orchards to over-bear at long intervals, or whenever all congenial natural conditions chance to be in unison. Tilled orchards tend to bear more continuously, but may not bear so heavily in occasional years. If the "bearing year" is ever to be controlled, tillage is the first step towards that end.

In other cases, sod orchards thrive because they have been well manured by the droppings of animals which are pastured in them; but the good results in these instances are due to fertilizing, not to sod. It does not follow, however, that this is the best way to fertilize orchards, although it has the great merit of expediency.

Sometimes seeding-down is the only practicable means of caring for an orchard, because the land is so hilly or rocky that it cannot be tilled.

There remain other instances in which sod seems to be a decided benefit to an orchard. These are cases in which it seems to be necessary to check growth on lands which are over-rich or which hold so much moisture that some of it can be profitably utilized in the growing of grass. On parts of the Cornell grounds, we think it necessary to seed down about fruit trees, because the land has been made so rich that the trees are over-growing and splitting down with the weight of top; but the seeding-down will be only a temporary expedient. The danger of too rapid growth is particularly great in peaches and grapes; it is very small with apple trees.

Everyone knows that sod is not good for strawberries, grapes, potatoes, corn, wheat or raspberries; the presumption is, therefore, that it is not good for apples or quinces. But apples, quinces and pears are tough, and it is surprising what little harm sod can do them when the land is good!

Fertilizing.—I am convinced that it will not yet pay to add commercial fertilizers to the general run of fruit plantations in New York. The tillage and other treatment are not good enough to warrant the extra expense. That is, the product is not of sufficient value to pay for any extra investment; and the land and trees are in such poor condition that the mere addition of fertilizer will be of little avail. But the better the tillage and the better the crops, the more it will pay, as a rule, to add fertilizers : the better a thing is, the more will it pay extra care and treatment. And the heavier an orchard bears in its youth, the greater is the presumption that it will need good care and fertilizing in its old age.

All this means that the best fruit-growers will generally find it profitable to use liberally of fertilizers. What fertilizers to use and how to apply them are subjects which are discussed in bulletins by many authors, and it is not necessary to refer to these details here ; but even after reading all the literature, the farmer must experiment with his own land and his own crops to determine just what materials are most profitable for his use. In other words, the advice as to fertilizers is more valuable in teaching a man principles, in suggesting means of experimenting, and in designating the probabilties of any line of action, than in specifying just what fertilizers one shall use. Various studies of the effects of fertilizers on horticultural crops have been made by this station, some of which will be published in due season. Of these, two may be mentioned here :

I. In 1894, an unprofitable apple orchard 25 years old, belonging to S. W. McCullom, Lockport, was examined by an expert, who thought that it needed potash. The orchard had been unproductive and had been in sod for some time. It stands on a rather hard dryish light clay loam, in which there are many small stones. The trees, Baldwin and Greening, are in good shape, and looked better than most apple trees do. Some trees received 10 pounds of nitrate of soda, sown as far as the spread of the limbs. Other trees received 10 pounds of muriate of potash, other 10 pounds of sulfate of potash, and others both muriate and sulfate. The materials were lightly plowed in, and the ground was then harrowed. The fertilizers were applied August 11, 1894. The orchard was plowed again in the fall of 1895, and again in the spring of 1896; and it is yet under tillage. In the season of 1895 no results were seen. In 1896, the nitrate-fertilized trees were remarkably darker colored than the others in foliage, more vigorous, and carried a heavier load of fruit. The difference in foliage could be detected at a distance of a half mile. In 1897, these trees were still superior to others, but the effects were not so marked as in the previous year. In 1898, all effects were lost, and the trees could not be distinguished from their neighbors. In 1896, the potash trees seemed to show a very slight gain, but no difference could be detected between the different potash treatments. In 1897 no effects were noticed; neither at fruiting time in 1898.

This experience is remarkable in two respects,—in showing how difficult it is to predict results with fertilizers in old orchards, and in the slowness with which the nitrate of soda worked. It was eighteen months before the effects of this dressing were seen; and yet nitrate of soda is soluble and is supposed to pass quickly through the soil. There are two explanations of this tardy action of the nitrate: this length of time may have been required to carry the material down to the roots, or the tree may not have recovered from its accustomed lethargy until the season following its appropriation of the nitrogen. This experience is further valuable in showing that the effect of nitrate lasted but two years.

II. In the orchard of J. J. McGowen, near Ithaca, experiments were begun in 1894 and 1896. The trees were 26 years old when tests were begun, and they had been continuously in sod after the first three years. They had been well top-dressed with stable manure for many years, however, and were in good bearing condition. The varieties are King and Baldwin.

Plot A. Plowed in the fall of 1894 and spring of 1895. At the latter time, sulfate of potash was applied at the rate of 750 lbs. to the acre. Clean tillage followed.

> The apples of 1895 were larger, and seven to ten days later than those on untreated trees.

In 1896 the tillage was continued, and on May 14 a heavy dressing was made of muriate of potash.

> Early in June, 1896, the foliage on the plot was seen to be unusually dark colored and vigorous. The difference could be seen a half mile. There was also a larger crop, not due to more profuse blossoming of the treated trees, but to less loss at the "June drop." The amount of fruit was about twice as great as on adjacent trees, and the apples were larger, later and lighter colored.

These results at once raised the question whether the potash or the tillage had influenced the trees. Consequently, two other plots were undertaken:

Plot B. Top-dressed in June, 1896, with 750 lbs. muriate potash per acre, and August, 1897, with sulfate potash, 750 lbs. to acre. Remains in sod.

Plot C. Plowed and tilled, from June 1896 to 1898. No fertilizer.

Plot A was continued in tillage, and in August, 1897, sulfate of potash was applied at the rate of 750 lbs. per acre.

In 1896, neither plot B or C showed any results.

In 1897, Plot A still had the darkest and best foliage and gave a slightly better yield than the remainder of the orchard; but the results were not so marked as in 1896. The apples were still larger and later.

In 1898, Plot A was still best, although the differences were very little. The fruit on this plot still ran larger than on others, and the owner thought, as in other years, that it was coarser and less sweet. Plots B and C seemed to show no gain over untreated trees.

Here, then, is an orchard, in good bearing condition, which was benefited by a treatment combining tillage and application of potash. Neither of these factors alone gave results. But the extra vigor and yield were at the expense of high color and early maturity. In the McCullom orchard the extra vigor of foliage, due to the nitrogen, seemed to be an unmixed blessing, although it should be said that the nitrogen-fertilized apples were Greenings, in which loss of color would not show. If there is any lesson to be drawn from these comparisons, it is that sod orchards which have been top-dressed systematically with stable manures may be expected to respond less profitably to remedial treatments than those which have not been so treated; but it does not follow that such orchards may not have given still better results if they had been both manured and tilled from the first. In other words, the better the habitual care of the fruit plantation, the less occasion the grower has to worry about it. These experiments also illustrate how different the problems are in different orchards, and how necessary it is that the farmer attempt to solve these local problems for himself by means of experiment. It is the custom to say that fruits need potassic fertilizers. This may he true as a general statement; but it does not follow that every plantation needs them.

Why are orchards barren?—This is one of the most difficult to answer of all agricultural questions,—why so many orchards are unproductive year after year. There are many causes of unproductiveness; and it is impossible to make an orchard young again in order that it may be brought up in the way it should go. It is a significant fact, however, that of many hundreds of barren orchards which I have inspected, less than half a dozen had received good tillage and other good care from the outset. In fact, barren orchards—of properly selected varieties—which have been well tilled, fertilized and otherwise well treated, are so rare that it is unnecessary to consider them in this discussion.

The most casual observer will agree that neglect is the common and general cause of barrenness in orchards. Even pigs are an unsatisfactory crop when they are obliged to shift for themselves. But it is the business of the experimenter to determine just which element of neglect is responsible for the failure in any particular case. I believe that the most general causes of barrenness are the following, being stated approximately in the order of their frequency and importance: (1) lack of good tillage, particularly in the first few years of the life of the plantation; (2) lack of humus and fertilizer; (3) uncongenial soils and sites; (4) lack of systematic annual pruning; (5) lack of spraying and of attention to borers and other pests; (6) bad selection of varieties; (7) trees propagated from unfruitful stock.

Seasons vary. Some years are good fruit years: in those years most orchards bear. In fact, they are likely to overbear; the trees are thereby depleted, and a bad year follows: the consequences are "bearing years" and "off years." The longer the conditions are allowed to dictate what the crops shall be, the more difficult it is to bring the plantation into a habit of annual bearing. I suspect that half the mature barren orchards of the State could not be made profitable by any line of treatment. They have had their own way too long. In most cases of barren orchards, something is fundamentally wrong; and fundamentals can not be changed in a day.

In the nature of the tree there is no reason why it should not bear more or less continuously. On the Cornell grounds is a Stark apple tree which was planted in 1890. It is in rich ground and has had good care. It is as large as most trees are at twelve years. It has borne five consecutive crops. In 1896 it bore two barrels of first-quality graded apples; in 1897 it had nearly as many; in 1898 it bore three barrels.

Varieties.—There is a decided tendency in this country to limit closely the number of varieties of any fruit when setting a plantation. Some of the most successful fruit-growers would limit the varieties of apples, pears or strawberries to three or four. Yet, as a matter of fact, the really good varieties of any fruit are usually numbered by scores, sometimes by hundreds, and valuable novelties are always being introduced. Here, then, is a conflict. If the advice of fruit-growers is to be followed, it would seem that the introduction of novelties is unnecessary; and yet without novelties, progress in varieties is impossible.

It is true that varieties should be few in most plantations, but the reason is that most American fruit-growers are raising fruits for the general or open markets; and in these markets, uniformity of product is almost imperative. But if it is fatal to grow many varieties when the world's markets are in view, it may be equally unsatisfactory to grow very few varieties when special or personal markets are in view.

I believe that the tendency is to go too far in the reduction of varieties. We are reducing fruit-growing to a single ideal and are thereby increasing the competition in that direction. There are varieties for different uses, different soils, and different geographical regions; and a variety which fails in every region but one, may still be worth introducing. It is the commonest mistake to recommend a variety for any region merely because it thrives in some other region. Because the Ben Davis is eminently successful in the mid-continental region, is no reason for supposing that it will be equally good in New York; in fact, it is a presumption against its thriving equally well in New York, for a variety rarely does equally well everywhere. A fruit-grower in western New York asked me if I would advise him to plant Arkansas apples. I told him no; but I advised him to test them.

A variety which is suited only to the general market, is most profitable in that region in which it thrives best. It is doubtful, for instance, if the New York grower can compete long in Kieffer pears with growers in the middle and southern states; and it is certain that those regions cannot compete with New York in Bartletts and Seckels. Wherever a fruit reaches its highest development, there it should be grown; and local varieties are often best adapted to local and personal markets.

The nurseries grow fruit trees to supply the demand for general-purpose varieties; and as a consequence they tend to reduce varieties and to make them uniform over the whole country. Many of the fine dessert varieties cannot be obtained at nurseries. With the refinement of our horticulture more varieties will be grown. The more fully the horticulture of any country is developed, the more perfectly are the various localities and needs supplied. In this direction we have much to learn from Europe, for one is there impressed with the great numbers of varieties which are actually known and grown. But in Europe, the fruits are grown for local and personal markets; here we grow for the world's markets, and varieties must therefore be few in comparison.

Since the selection of varieties is a question of locality and of the personal ideals of the grower, it follows that those lists of varieties are most valuable, other things being equal, which are made by the most local and circumscribed societies.

Does spraying pay?—The past season has given strange results in spraying. In very many instances spraying seemed to do no good. Does spraying pay, then? Certainly, the same as tillage and pruning do. We do not know why there were so many unsatisfactory experiences in 1898; but this does not lessen the fact that bugs and fungi should be killed. That spraying pays is as well demonstrated as it is that apple-worms, tent-caterpillars and potato-blight are injurious. Markets often fail, but it does not follow that markets are a nuisance. The safest way is to make it a rule to spray everything every year, and then to break the rule when one is sure that the combination of circumstances is such that spraying is not necessary. This means that the fruit-farmer must master the reasons and the principles, and then apply them as circumstances demand. As a rule, the better the results of spraying the better has the operator conceived of his own local problems. If the fruit-grower follows this advice, he will probably find himself spraying apples and pears and quinces every year; and he will be more than likely to do the same for plums, grapes and strawberries.

In no one of the applications of science-teaching to fruit-growing has the American so clearly the advantage of the European as in the knowledge of insect and fungous pests and of means of dispatching them. The superiority of the American fruit as a general-market product, is due to a considerable degree to spraying. The American, of all men, should be the last to ask if spraying pays.

L. H. Bailey

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Bulletin 154. **November, 1898.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

AGRICULTURAL DIVISION.

TABLES FOR
COMPUTING RATIONS
FOR
FARM ANIMALS.

By J. L. STONE.

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COMPUTING RATIONS FOR FARM ANIMALS.

For more than a third of a century the subject of feeding to farm animals a "balanced ration" or one that conforms quite closely to a "standard" that has been fixed by carefully conducted experiments with the kind of animal for which it is recommended, has been before American stock feeders. The general utility of feeding standards is almost universally admitted by those who have given the matter study, and the number of feeders who are endeavoring to conform their practices to the standards is continually increasing.

The tables of feeding stuffs and the methods of using them have been much simplified of late years, but judging by the large number of requests from farmers, received by the agricultural papers and the Experiment Stations, for formulas of balanced rations, adapted to the needs of the inquirers, the subject is still too complicated, or the labor involved too great, to be readily accomplished by the ordinary farmer. It is with a view of further simplifying the computation of rations and bringing it within the range of every feeder that the accompanying tables have been prepared. The effort has been to carry the computations as near to completion as possible, so that the user will simply need to take from the table the figures corresponding to the kinds and amounts of the feeds used in the proposed ration and add them together to be able to compare it with the standard. The only advantage claimed for this publication is that by the arrangement of the tables and by the computations made, the labor of formulating rations is very materially reduced, and it is hoped that many who have not heretofore attempted this work for themselves will be encouraged to do so.

PRINCIPLES OF FEEDING.

The various substances found in animal bodies may for convenience be grouped under four heads: water; ash, or mineral matter; fat, and nitrogenous matter or protein. These substances occur in the animal body in somewhat varying proportions, depending upon age, condition, treatment, etc.

Water is an essential constituent of the animal body and constitutes from 40 to 60 per cent of its live weight. Ash occurs mainly in the bones and constitutes from two to five per cent of the live weight. The fat occurs in greatly varying proportions, but rarely is less than six or more than thirty per cent. All those substances containing nitrogen are classed as protein. They constitute an important group of which washed lean meat and the white of egg may be taken as types. They contain about 16 per cent of the element nitrogen and are the only class into the composition of which this element enters. All the working machinery of the body, such as flesh, skin, bones, hair, internal organs, brain and nerves, contain a large proportion of protein.

COMPOSITION OF FOOD MATERIALS.

The same four groups of substances found in animal bodies, viz.: water, ash, fat and protein, are also found in the food they consume and in addition the food of herbivorous animals contains a class called carbohydrates.

Water.—All food stuffs, no matter how dry they may seem, contain a considerable amount of water. In grains and dried fodders it ranges from 8 to 15 per cent of the material, in green forage and silage it is about 80 per cent, while in some roots it amounts to 90 per cent. While water is essential to animal life and the water in the food fulfills the same function as that drunk by the animal, we do not value food materials for the water they contain, and computations are based upon the water-free or dry matter.

Ash.—When a food stuff is burned till the organic matter is all driven off the residue is the ash. It is composed largely of lime, magnesia, potash, soda, iron, chlorine, and carbonic, sulfuric and phosphoric acids. The ash of the food is the source of the mineral matter of the animal body and as such is of great importance. Ordinary combinations of feeding stuffs, however, contain an abundant supply of mineral matter for the use of the animal, so it is not a matter of practical concern except as it has a bearing on the mineral elements of fertility in the manure.

Fats.—This group embraces the materials which may be dissolved from a feeding stuff by ether. It includes, besides the true fats, wax and coloring matter. Fat in the food may be either stored in the body as fat, or burned to produce heat and energy.

Carbohydrates.—This term includes two groups, nitrogen-free extract, such as starch, sugar, gum, etc., and fiber or the woody part of plants. The former are quite freely digested, the latter much less so, though fulfilling the same function to the extent it is digested. The carbohydrates constitute the largest part of vegetable foods. They are not stored in the animal body as such, but are converted into fat or used (burned) to produce heat and energy.

Since the carbohydrates and fat serve nearly the same purpose in the animal economy, they may, for convenience, be grouped together. Experiments, however, have shown that fat is about 2¼ times as effective as a food as are the carbohydrates. Hence it is customary to multiply the amount of fat by 2¼ to reduce it to a "starch equivalent" before adding it to the amount of the carbohydrates.

Protein.—The protein of foods, like that of the animal body, is characterized by containing nitrogen. It, therefore, is frequently termed "*nitrogenous* matter." Ths term *albumenoids* is sometimes used to designate this group, though it more correctly implies a certain class of protein substances. The function of protein in the food is, first of all, to build up and repair the working machinery of the body, and to supply protein for the production of milk, wool, etc. No other food constituent can fulfill this function.

The importance of a sufficient supply of protein in the ration is, therefore, apparent. If in excess of the amount required to build up and repair the waste of the body the protein may be converted into fat and deposited as such or used to produce heat and energy. Its efficiency for these purposes is about the same as the carbohydrates, but as it is usually far more expensive to supply than the carbohydrates, economy would dictate that only so much should be supplied to the animal as will suffice to repair the wastes of the animal machinery and build up new growth in case of growing animals, or for the production of milk, wool, etc.

COMPOUNDING OF RATIONS.

Nutritive ratio.—Since the protein on the one hand and the carbohydrates and fat on the other, serve, in the main, different purposes in the animal economy, it becomes evident that the relative amounts of these nutritients in the food are important. This relation is expressed as the "nutritive ratio," which means the relation of digestible protein to digestible carbohydrates and fat—the fat having been multiplied by 2¼ before adding to the carbohydrates, as explained above. The nutritive ratio is found by dividing the carbohydrates, plus 2¼ times the fat, by the protein. In the accompanying table, No. II, the sum of the carbohydrates and fat, thus obtained, is given in the third column, which divided by the protein as given in the second column gives the second term of the nutritive ratio in the fifth column.

A feeding stuff having a large proportion of carbohydrates and fat as compared to protein is said to have a "wide" nutritive ratio, while one having a small proportion of carbohydrates and fat as compared to protein has a "narrow" ratio. While these terms are relative, it may be said that a ratio greater than 1:6 is wide while one less that 1:5 is narrow. The composition of feeding stuffs, that is the proportion in which the different nutrients occur, is determined by chemical analysis, but the amount of each nutrient that is actually digestible has been determined by careful experiments with living animals. Only the digestible nutrients are considered in the tables given in this publication.

Feeding Standards.—The amount of nutrients required and the proportions in which each should be given, varies with the kind of animal and the purpose for which it is kept; whether it is growing, being fattened, doing work, or producing milk or wool. Thus an ox at rest requires less food and the various nutrients in different proportions than an ox at work; a cow producing milk requires more food and the nutrients differently balanced than one not producing.

Various investigators have condensed the results of many experiments and much practical experience into what are called "feeding standards," which attempt to state what is in general, and under average conditions, a good ration for the purpose in view. While these standards cannot be considered as mathematically exact, still large practical experience has demonstrated their great value as aids to feeders.

In Table I, under the title of Feeding Standards, are given the approximate requirements of various classes of animals and under varying conditions. These standards are mostly from German sources, but they have been found very helpful to American feeders. They are presented here as arranged by Armsby, in Circular of Information No. 1, "Computation of Rations for Farm Animals," Penna. State College. The standards are for animals of 1,000 lbs. live weight, and may be increased or diminished for larger or smaller animals, though it is probable that the individuality of the animal, its power to assimilate and produce, will have more to do with the varying of the ration than its weight. It is permissible, perhaps, to depart from the amounts given in the first column under the head of "Dry Matter," more than in any other way. The digestive apparatus of farm animals is elastic and accommodates itself quite readily to the varying bulk of its food. In the last column is given the nutritive ratio, which should, perhaps, be adhered to with some care, trusting to the appetite of the animal (which will be controlled largely by its power of digesting and producing) to indicate the amount of nutrients required. As a rule the most rapid fattening or growth and abundant production are most economical, and these results are best secured by feeding an abundant and well balanced ration (well up to the limit of the animal's appetite) while the dry matter is not permitted to rise much above the standard.

TABLE I.

FEEDING STANDARDS.

A—Per day and 1,000 pounds live weight.*

	Dry matter.	Digestible.			Nutritive ratio.
		Protein	Carbohydrates and fat.	Total.	
	Lbs.	*Lbs*	*Lbs.*	*Lbs.*	
Oxen at rest in stall	17.5	0.7	8.3	9.0	1:11.9
Wool sheep, coarser breeds	20.0	1.2	10.8	12.0	1:9.0
Wool sheep, finer breeds	22.5	1.5	12.0	13.5	1:8.0
Oxen moderately worked	24.0	1.6	12.0	13.0	1:7.5
Oxen heavily worked	26.0	2.4	14.3	16.7	1:6.0
Horses lightly worked	20.0	1.5	10.4	11.9	1:6.9
Horses moderately worked	21.0	1.7	11.8	13.5	1:6.9
Horses heavily worked	23.0	2.3	14.3	16.6	1:6.2
Milk cows, Wolff's standard	24.0	2.5	13.4	15.9	1:5.4
Milk cows, Wisconsin standard	24.5	2.2	14.9	17.1	1:6.8
Fattening oxen, preliminary period	27.0	2.5	16.1	18.6	1:6.4
Fattening oxen, main period	26.0	3.0	16.4	19.4	1:5.5
Fattening oxen, finishing period	25.0	2.7	16.2	18.9	1.6.0
Fattening sheep, preliminary period	26.0	3.0	16.3	19.3	1:5.4
Fattening sheep, main period	25.0	3.5	15.8	19.3	1:4.5
Fattening swine, preliminary p'riod	36.0	5.0	27.5	32.5	1:5.5
Fattening swine, main period	31.0	4.0	24.0	28.0	1:6.0
Fattening swine, finishing period	23.5	2.7	17.5	20.2	1:6.5
Growing cattle:					
Age. Months — *Average live weight per head.*					
2–3 — 150 lbs	22.0	4.0	18.3	22.3	1:4.6
3-6 — 300 lbs	23.4	3.2	15.8	19.0	1:4.9
6-12 — 500 lbs	24.0	2.5	14.9	17.4	1:6.0
12–18 — 700 lbs	24.0	2.0	13.9	15.9	1:7.0
18 24 — 850 lbs	24.0	1.6	12.7	14.3	1:8.0
Growing sheep:					
5-6 — 56 lbs	28.0	3.2	17.4	20.6	1:5.4
6–8 — 67 lbs	25.0	2.7	14.7	17.4	1:5.4
8-11 — 75 lbs	23.0	2.1	12.5	14.6	1:6.0
11–15 — 82 lbs	22.5	1.7	11.8	13.5	1:7.0
15–20 — 85 lbs	22.0	1.4	11.1	12.5	1:8.0
Growing fat pigs:					
2-3 — 50 lbs	42.0	7.5	30.0	37.5	1:4.0
3 5 — 100 lbs	34.0	5.0	25.0	30.0	1:5.0
5-6 — 125 lbs	31.5	4.3	23.7	28.0	1:5.5
6-8 — 170 lbs	27.0	3.4	20.4	23.8	1:6.0
8–12 — 250 lbs	21.0	2.5	16.2	18.7	1:6.5

B—Per day and per head.

	Dry matter.	Protein	Carbohydrates and fat.	Total.	Nutritive ratio.
Growing cattle:					
2-3 — 150 lbs	3.3	0.6	2.8	3.4	1:4.6
3-6 — 300 lbs	7.0	1.0	4.9	5.9	1:4.9
6 12 — 500 lbs	12.0	1.3	7.5	8.8	1:6.0
12–18 — 700 lbs	16.8	1.4	9.7	11.1	1:7.0
18–24 — 850 lbs	20.4	1.4	11.1	12.5	1:8.0
Growing sheep:					
5–6 — 56 lbs	1.6	0.18	0.974	1.154	1:5.4
6–8 — 67 lbs	1.7	0.18	0.981	1.161	1:5.4
8-11 — 75 lbs	1.7	0.16	0.953	1.113	1:6.0
11–15 — 82 lbs	1.8	0.14	0.975	1.115	1:7.0
15–20 — 85 lbs	1.9	0.12	0.955	1.075	1:8.0
Growing fat swine:					
2–3 — 50 lbs	2.1	0.38	1.50	1.88	1:4.0
3–5 — 100 lbs	3.4	0.50	2.50	3.00	1:5.0
5-6 — 125 lbs	3.9	0.54	2.96	3.50	1:5.5
6–8 — 170 lbs	4.6	0.58	3.47	4.05	1:6.0
8–12 — 250 lbs	5.2	0.62	4.05	4.67	1:6.5

* The fattening rations are calculated for 1,000 lbs. live weight at the beginniug of the fattening.

Table II gives a list of the feeding stuffs in most common use in New York state. Column one is headed "dry matter;" column two, "digestible protein;" column three, "digestible carbohydrates + (fat × 2¼);" column four, "total" (which is the sum of two and three); column five, "nutritive ratio." In each of these columns is given the computations of the various food stuffs from one pound up to the amount that is likely to be used in compounding any ration. In the case of the coarse fodders, to save space, the increase is made by more than one pound at a time, but intermediate amounts can readily be obtained from the table if desired. In no case are the calculations for *ten lbs.* of a feeding stuff given, as these can be obtained at once from the figures for one pound, by simply moving the decimal point one place to the right.

These computations are based upon the table of "Average Digestible Nutrients in American Feeding Stuffs" given in Prof. W. A. Henry's recent book, "Feeds and Feeding." The aim has been to carry the computations involved in formulating rations as near completion as possible, and to present the figures in such simple form that no feeder will have difficulty in comparing the ration he is feeding with the standards and correcting it, if necessary, to conform thereto.

TABLE NO. II.

DIGESTIBLE NUTRIENTS IN THE STATED AMOUNTS OF THE MORE COMMON FEEDING STUFFS.

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
SOILING FODDER.					
Fodder corn, 1 lb	.20	.010	.125	.135	1:12.5
" " 5 lbs	1.00	.050	.625	.675	
" " 15 "	3.00	.150	1.875	2.025	
" " 20 "	4.00	.200	2.500	2.700	
" " 25 "	5.00	.250	3.125	3.375	
" " 30 "	6.00	.300	3.750	4.050	
" " 35 "	7.00	.350	4.375	4.725	
" " 40 "	8.00	.400	5.000	5.400	
Peas and oats, 1 lb	.16	.018	.076	.094	1:4.2
" " 5 lbs	.80	.090	.380	.470	
" " 15 "	2.40	.270	1.140	1.410	
" " 20 "	3.20	.360	1.520	1.880	
" " 25 "	4.00	.450	1.900	2.350	
" " 30 "	4.80	.540	2.280	2.820	
" " 35 "	5.60	.630	2.660	3.290	
" " 40 "	6.40	.720	3.040	3.760	
Peas and barley	.16	.017	.077	.094	1:4.5
Practically the same as peas and oats.					
Red clover, 1 lb	.29	.029	.164	.193	1:5.6
" " 5 lbs	1.45	.145	.820	.965	
" " 15 "	4.35	.435	2.460	2.895	
" " 20 "	5.80	.580	3.280	3.860	
" " 25 "	7.25	.725	4.100	4.825	
" " 30 "	8.70	.870	4.920	5.790	
" " 35 "	10.15	1.015	5.740	6.755	
" " 40 "	11.60	1.160	6.560	7.720	
Alfalfa, 1 lb	.28	.039	.138	.177	1:3.5
" 5 lbs	1.40	.195	.690	.885	
" 15 "	4.20	.585	2.070	2.655	
" 20 "	5.60	.780	2.760	3.540	
" 25 "	7.00	.975	3.450	4.425	
" 30 "	8.40	1.170	4.140	5.310	
" 35 "	9.80	1.365	4.830	6.195	
" 40 "	11.20	1.560	5.520	7.080	
Hungarian grass, 1 lb	.29	.020	.169	.189	1:8.4
" " 5 lbs	1.45	.100	.845	.945	
" " 15 "	4.35	.300	2.535	2.835	
" " 20 "	5.80	.400	3.380	3.780	

TABLE No. II.—*Continued*.

Kind and amount of feed.	Total dry matter.	Pounds of digestible trinuents.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Hungarian grass, 25 lbs ...	7.25	.500	4.225	4.725	
" " 30 "	8.70	.600	5.070	5.670	
" " 35 "	10.15	.700	5.915	6.615	
" " 40 "	11.60	.800	6.760	7.560	
Corn silage 1 lb........	.21	.009	.129	.138	1:14.3
" " 5 lbs........	1.05	.045	.645	.690	
" " 15 "	3.15	.135	1.935	2.070	
" " 20 "	4.20	.180	2.580	2.760	
" " 25 "	5.25	.225	3.225	3.450	
" " 30 "	6.30	.270	3.870	4.140	
" " 35 "	7.35	.315	4.515	4 830	
" " 40 "	8.40	.360	5.160	5.520	
" " 45 "	9.45	.405	5.805	6.210	
" " 50 "	10.50	.450	6.450	6.900	
ROOTS AND TUBERS.					
Potatoes 1 lb.............	.21	.009	.165	.174	1:18.3
" 5 lbs.	1.05	.045	.825	.870	
" 15 "	3.15	.135	2.475	2.610	
" 20 "	4.20	.180	3.300	3 480	
" 25 "	5.25	.225	4.125	4.350	
Beet, mangel 1 lb.........	.09	.011	.056	.067	1:5.1
" " 5 lbs........	.45	.055	.280	.335	
" " 15 "	1.35	.165	.840	1.005	
" " 20 "	1.80	.220	1.120	1.340	
" " 25 "	2.25	.275	1.400	1.675	
" " 30 "	2.70	.330	1.680	2.010	
Beet, sugar 1 lb.........	.13	.011	.104	.115	1:9.4
" " 5 lbs	.65	.055	.520	.575	
" " 15	1.95	.165	1.560	1.725	
" " 20	2.60	.220	2.080	2.300	
" " 25	3.25	.275	2.600	2.875	
" " 30	3.90	.330	3.120	3.450	
Carrot 1 lb	.11	.008	.082	.090	1:10.3
" 5 lbs.............	.55	.040	.410	.450	
" 15 "	1.65	.120	1.230	1.350	
" 20 "	2.20	.160	1.640	1.800	
" 25 "	2.75	.200	2.050	2.250	
" 30 "	3.30	.240	2.460	2.700	
HAY AND STRAW.					
Timothy 1 lb.............	.87	.028	.465	.493	1:16.6
" 3 lbs............	2.61	.084	1.395	1.479	
" 5 "	4.35	.140	2.325	2.465	

TABLE No. II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Corbohydrates + (fat × 2.25.)	Total.	
Timothy, 7 lbs.	6.09	.196	3.255	3.451	
" 8 "	6.96	.224	3.720	3.944	
" 9 "	7.83	.252	4.185	4.437	
" 12 "	10.44	.336	5.580	5.916	
" 15 "	13.05	.420	6.975	7.395	
" 18 "	15.66	.504	8.370	8.874	
" 20 "	17.40	.560	9.300	9.860	
Mixed grasses and clover, 1 lb.	.87	.062	.460	.522	1:7.4
" 3 lbs	2.61	.186	1.381	1.566	
" 5 "	4.35	.310	2.300	2.610	
" 7 "	6.09	.434	3.220	3.654	
" 8 "	6.96	.496	3.680	4.176	
" 9 "	7.83	.558	4.140	4.698	
" 12 "	10.44	.744	5.520	6.264	
" 15 "	13.05	.930	6.900	7.830	
" 18 "	15.66	1.116	8.280	9.396	
" 20 "	17.40	1.240	9.200	10.440	
Hungarian hay, 1 lb.	.92	.045	.546	.591	1:12.1
" " 3 lbs	2.76	.135	1.638	1.773	
" " 5 "	4.60	.225	2.730	2.955	
" " 7 "	6.44	.315	3.822	4.137	
" " 8 "	7.36	.360	4.368	4.728	
" " 9 "	8.28	.405	4.914	5.319	
" " 12 "	11.04	.540	6.552	7.092	
Red clover hay, 1 lb.	.85	.068	.396	.464	1:5.8
" " 3 lbs	2.55	.204	1.188	1.392	
" " 5 "	4.25	.340	1.980	2.320	
" " 7 "	5.95	.476	2.772	3.248	
" " 8 "	6.80	.544	3.168	3.712	
" " 9 "	7.65	.612	3.564	4.176	
" " 12 "	10.20	.816	4.752	5.568	
" " 15 "	12.75	1.020	5.940	6.960	
" " 18 "	15.30	1.224	7.128	8.352	
" " 20 "	17.00	1.360	7.920	9.280	
Alfalfa hay, 1 lb.	.92	.110	.423	.533	1:3.8
" " 3 lbs	2.76	.330	1.269	1.599	
" " 5 "	4.60	.550	2.115	2.665	
" " 7 "	6.44	.770	2.961	3.731	
" " 8 "	7.36	.880	3.384	4.264	
" " 9 "	8.28	.990	3.807	4.797	
" " 12 "	11.04	1.320	5.076	6.396	
" " 15 "	13.80	1.650	6.345	7.995	
" " 18 "	16.56	1.980	7.614	9.594	
" " 20 "	18.40	2.200	8.460	10.660	

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Corn fodder 1 lb	.58	.025	.373	.398	1:14.9
" 5 lbs	2.90	.125	1.865	1.990	
" 8 "	4.64	.200	2.984	3.184	
" 12 "	6.96	.300	4.476	4.776	
" 15 "	8.70	.375	5.595	5.970	
" 18 "	10.44	.450	6.714	7.164	
" 20 "	11.60	.500	7.460	7.960	
Corn stover 1 lb	.60	.017	.340	.357	1:19.9
" 5 lbs..........	3.00	.085	1.720	1.785	
" 8 "	4.80	.136	2.720	2.856	
" 12 "	7.20	.204	4.080	4.284	
" 15 "	9.00	.255	5.160	5.355	
" 18 "	10.80	.306	6.120	6.426	
" 20 "	12.00	.340	6.880	7.140	
Pea-vine straw 1 lb.......	.86	.043	.341	.384	1: 7.9
" " 3 lbs......	2.58	.129	1.023	1.152	
" " 5 "	4.30	.215	1.705	1.920	
" " 8 "	6.88	.344	2.728	3.072	
" " 12 "	10.32	.516	4.092	4.608	
" " 15 "	12.90	.645	5.115	5.760	
Wheat straw 1 lb	.90	.004	.372	.376	1:93.
" 3 lbs........	2.70	.012	1.016	1.128	
" 5 "	4.50	.020	1.860	1.880	
" 8 "	7.20	.032	2.976	3.008	
" 12 "	10.80	.048	4.064	4.512	
" 15 "	13.50	.060	5.580	5.640	
Oat straw 1 lb	.91	.012	.404	4.16	1:33.6
" 3 lbs............	2.73	.036	1.212	1.248	
" 5 "	4.55	.060	2.020	2.080	
" 8 "	7.28	.096	3.232	3.328	
" 12 "	10.92	.144	4.848	4.992	
" 15 "	13.65	.180	6.060	6.240	
GRAIN.					
Corn (av.) 1 lb	.89	.079	.764	.843	1: 9.7
" 2 lbs..........	1.78	.158	1.528	1.686	
" 3 "	2.67	.237	2.292	2.529	
" 4 "	3.56	.316	3.056	3.372	
" 5 "	4.45	.395	3.820	4.215	
" 6 "	5.34	.474	4.584	5.058	
" 7 "	6.23	.553	5.348	5.901	
" 8 "	7.12	.632	6.112	6.744	
" 9 "	8.01	.711	6.876	7.587	

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total	
Wheat, 1 lb	.90	.102	.730	.832	1:7.2
" 2 lbs	1.80	.204	1.460	1.664	
" 3 "	2.70	.306	2.190	2.496	
" 4 "	3.60	.408	2.920	3.328	
" 5 "	4.50	.510	3.650	4.160	
" 6 "	5.40	.612	4.380	4.992	
Rye, 1 lb	.88	.099	.700	.799	1:7.1
" 2 lbs	1.76	.198	1.400	1.598	
" 3 "	2.64	.297	2.100	2.397	
" 4 "	3.52	.396	2.800	3.196	
" 5 "	4.40	.495	3.500	3.995	
" 6 "	5.28	.594	4.200	4.794	
Barley, 1 lb	.89	.087	.692	.779	1:7.9
" 2 lbs	1.78	.174	1.384	1.558	
" 3 "	2.67	.261	2.076	2.337	
" 4 "	3.56	.348	2.768	3.116	
" 5 "	4.45	.435	3.460	3.895	
" 6 "	5.34	.522	4.152	4.674	
Oats, 1 lb	.89	.092	.568	.660	1:6.2
" 2 lbs	1.78	.184	1.136	1.320	
" 3 "	2.67	.276	1.704	1.980	
" 4 "	3.56	.368	2.272	2.640	
" 5 "	4.45	.460	2.840	3.300	
" 6 "	5.34	.552	3.408	3.960	
" 7 "	6.23	.644	3.976	4.620	
" 8 "	7.12	.736	4.544	5.280	
" 9 "	8.01	.828	5.112	5.940	
" 12 "	10.68	1.104	6.816	7.920	
" 15 "	13.35	1.380	8.520	9.900	
Buckwheat, 1 lb	.87	.077	.533	.610	1:6.9
" 2 lbs	1.74	.154	1.066	1.220	
" 3 "	2.61	.231	1.599	1.830	
" 4 "	3.48	.308	2.132	2.440	
" 5 "	4.35	.385	2.665	3.050	
" 6 "	5.22	.462	3.198	3.660	
" 7 "	6.09	.539	3.731	4.270	
" 8 "	6.96	.616	4.264	4.880	
" 9 "	7.83	.693	4.797	5.490	
Peas, 1 lb	.90	.168	.534	.702	1:3.2
" 2 lbs	1.80	.336	1.068	1.404	
" 3 "	2.70	.504	1.602	2.106	
" 4 "	3.60	.672	2.136	2.808	

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Peas, 5 lbs.	4.50	.840	2.670	3.510	
" 6 "	5.40	1.008	3.204	4.212	
" 7 "	6.30	1.176	3.738	4.914	
" 8 "	7.20	1.344	4.272	5.616	
" 9 "	8.10	1.512	4.806	6.318	
MILL PRODUCTS.					
Corn and cob meal, 1 lb	.85	.044	.665	.709	1:15.1
" " 2 lbs.	1.70	.088	1.330	1.418	
" " 3 "	2.55	.132	1.995	2.127	
" " 4 "	3.40	.176	2.660	2.836	
" " 5 "	4.25	.220	3.325	3.545	
" " 6 "	5.10	.264	3.990	4.254	
" " 7 "	5.95	.308	4.655	4.963	
" " 8 "	6.80	.352	5.320	5.672	
" " 9 "	7.65	.396	5.985	6.381	
" " 12 "	10.20	.528	7.980	8.508	
Wheat bran, 1 lb.	.88	.122	.453	.575	1:3.7
" " 2 lbs.	1.76	.244	.906	1.150	
" " 3 "	2.64	.366	1.359	1.725	
" " 4 "	3.52	.488	1.812	2.300	
" " 5 "	4.40	.610	2.265	2.875	
" " 6 "	5.28	.732	2.718	3.450	
" " 7 "	6.16	.854	3.171	4.025	
" " 8 "	7.04	.976	3.624	4.600	
" " 9 "	7.92	1.098	4.077	5.175	
Wheat middlings, 1 lb	.88	.128	.607	.735	1:4.7
" " 2 lbs	1.76	.256	1.214	1.470	
" " 3 "	2.64	.384	1.821	2.205	
" " 4 "	3.52	.512	2.428	2.940	
" " 5 "	4.40	.640	3.035	3.675	
" " 6 "	5.28	.768	3.642	4.410	
" " 7 "	6.16	.896	4.249	5.145	
" " 8 "	7.04	1.024	4.856	5.880	
" " 9 "	7.92	1.152	5.463	6.615	
Dark feeding flour, 1 lb.	.90	.135	.658	.793	1:4.9
" " 2 lbs.	1.80	.270	1.316	1.586	
" " 3 "	2.70	.405	1.974	2.379	
" " 4 "	3.60	.540	2.632	3.172	
" " 5 "	4.50	.675	3.290	3.965	
" " 6 "	5.40	.810	3.948	4.758	
" " 7 "	6.30	.945	4.606	5.551	
" " 8 "	7.20	1.080	5.264	6.344	
" " 9 "	8.10	1.215	5.922	7.137	

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Low grade flour, 1 lb......	.88	.082	.647	.729	1:7.9
" " " 2 lbs.....	1.76	.164	1.294	1.458	
" " " 3 "	2.64	.246	1.941	2.187	
" " " 4 "	3.52	.328	2.588	2.916	
" " " 5 "	4.40	.410	3.235	3.645	
" " " 6 "	5.28	.492	3.882	4.374	
" " " 7 "	6.16	.574	4.529	5.103	
" " " 8 "	7.04	.656	5.176	5.832	
" " " 9 "	7.92	.738	5.823	6.561	
Rye bran, 1 lb............	.88	.115	.548	.663	1:4.8
" " 2 lbs..........	1.76	.230	1.096	1.326	
" " 3 "	2.64	.345	1.644	1.989	
" " 4 "	3.52	.460	2.192	2.652	
" " 5 "	4.40	.575	2.740	3.315	
" " 6 "	5.28	.690	3.288	3.978	
" " 7 "	6.16	.805	3.836	4.641	
" " 8 "	7.04	.920	4.384	5.304	
" " 9 "	7.92	1.035	4.952	5.967	
Buckwheat bran, 1 lb.....	.90	.074	.347	.421	1:4.7
" " 2 lbs.....	1.80	.148	.694	.842	
" " 3 "	2.70	.222	1.041	1.263	
" " 4 "	3.60	.296	1.388	1.684	
" " 5 "	4.50	.370	1.735	2.105	
" " 6 "	5.40	.444	2.082	2.526	
" " 7 "	6.30	.518	2.429	2.847	
" " 8 "	7.20	.592	2.776	3.368	
" " 9 "	8.10	.666	3.123	3.789	
Buckwheat middlings, 1 lb.	.87	.220	.456	.676	1:2.1
" " 2 lbs.	1.74	.440	.912	1.352	
" " 3 "	2.61	.660	1.368	2.028	
" " 4 "	3.48	.880	1.824	2.704	
" " 5 "	4.35	1.100	2.280	3.380	
" " 6 "	5.22	1.320	2.736	4.056	
" " 7 "	6.09	1.540	3.192	4.732	
" " 8 "	6.96	1.760	3.648	5.408	
" " 9 "	7.83	1.980	4.104	6.084	
BYE-PRODUCTS.					
Malt sprouts, 1 lb........	.90	.186	.409	.595	1:2.2
" " 2 lbs	1.80	.372	.818	1.190	
" " 3 "	2.70	.558	1.227	1.785	
" " 4 "	3.60	.744	1.636	2.380	
" " 5 "	4.50	.930	2.045	2.975	
" " 6 "	5.40	1.116	2.454	3.570	

TABLE. II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrate + (fats × 2.25).	Total.	
Malt Sprouts 7 lbs.......	6.30	1.302	2.863	4.165	
" 8 "	7.20	1.488	3.272	4.760	
" 9 "	8.10	1.674	3.681	5.355	
Brewer's grains, wet 1 lb.	.24	.039	.125	.164	1:3.2
" " 2 lbs.	.48	.078	.250	.328	
" " 3 "	.72	.117	.375	.492	
" " 4 "	.96	.156	.500	.656	
" " 5 "	1.20	.195	.625	.820	
" " 6 "	1.44	.234	.750	.984	
" " 7 "	1.68	.273	.875	1.148	
" " 8 "	1.92	.312	1.000	1.312	
" " 9 "	2.16	.351	1.125	1.476	
" " 11 "	2.64	.429	1.375	1.804	
" " 12 "	2.88	.468	1.500	1.968	
" " 15 "	3.60	.585	1.875	2.460	
Brewer's grains, dry 1 lb..	.92	.157	.478	.635	1:3
" " 2 lbs.	1.84	.314	.956	1.270	
" " 3 "	2.76	.471	1.434	1.905	
" " 4 "	3.68	.628	1.912	2.540	
" " 5 "	4.60	.785	2.390	3.175	
" " 6 "	5.52	.942	2.868	3.810	
" " 7 "	6.44	1.099	3.346	4.445	
" " 8 "	7.36	1.256	3.824	5.080	
" " 9 "	8.28	1.413	4.302	5.715	
Gluten feed* 1 lb......	.92	.194	.633	.827	1:3.3
" 2 lbs.......	1.84	.388	1.266	1.654	
" 3 "	2.76	.582	1.899	2.481	
" 4 "	3.68	.776	2.532	3.308	
" 5 "	4.60	.970	3.165	4.135	
" 6 "	5.52	1.164	3.798	4.962	
" 7 "	6.44	1.358	4.431	5.789	
" 8 "	7.36	1.552	5.064	6.616	
Gluten meal 1 lb........	.92	.258	.656	914	1:2.5
" 2 lbs......	1.84	.516	1.312	1.828	
" 3 "	2.76	.774	1.968	2.742	
" 4 "	3.68	1.032	2.624	3.656	
" 5 "	4 60	1.290	3.280	4.570	
" 6 "	5.52	1.548	3.936	5.484	
" 7 "	6.44	1.806	4.592	6.398	
" 8 "	7.36	2.064	5.248	7.312	
Hominy Chop 1 lb.......	.89	.075	.705	.780	1:9.4
" 2 lbs......	1.78	.150	1.410	1.560	
" 3 "	2.67	.225	2.115	2.340	

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* From Bulletin of Information No. 1, Penna. State College.

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25.)	Total.	
Hominy chop, 4 lbs......	3.56	.300	2.820	3.120	
" " 5 "	4.45	.375	3.525	3.900	
" " 6 "	5.34	.450	4.230	4.680	
" " 7 "	6.23	.525	4.935	5.460	
" " 8 "	7.12	.600	5.640	6.240	
" " 9 "	8.01	.675	6.345	7.020	
Linseed meal (old process), 1 lb.......	.91	.293	.485	.778	1:1.7
" " 2 lbs......	1.82	.586	.970	1.556	
" " 3 "	2.73	.879	1.455	2.334	
" " 4 "	3.64	1.172	1.940	3.112	
" " 5 "	4.55	1.465	2.425	3.890	
" " 6 "	5.46	1.758	2.910	4.668	
" " 7 "	6.37	2.051	3.395	5.446	
Linseed meal (new process), 1 lb	.90	.282	.464	.746	1:1.6
" " 2 lbs.....	1.80	.564	.928	1.492	
" " 3 "	2.70	.846	1.392	2.238	
" " 4 "	3.60	1.128	1.856	2.984	
" " 5 "	4.50	1 410	2.320	3.730	
" " 6 "	5.40	1.692	2.784	4.476	
" " 7 "	6.30	1.974	3.248	5.232	
Cotton-seed meal, 1 lb.....	.92	.372	.444	.816	1:1.2
" " 2 lbs....	1.84	.744	.888	1.632	
" " 3 "	2.76	1.116	1.332	2.448	
" " 4 " ...	3.68	1.488	1.776	3.264	
" " 5 "	4.60	1.860	2.220	4.080	
" " 6 "	5.52	2.232	2.664	4.896	
" " 7 " ...	6.44	2.604	3.008	5.712	
" " 8 "	7.36	2.976	3.552	6.528	
" " 9 "	8.28	3.348	3.996	7.344	
MISCELLANEOUS.					
Cabbage, 1 lb............	.15	.018	.091	.109	1:5.1
" 5 lbs...........	.75	.090	.455	.545	
" 15 "	2.25	.270	1.365	1.635	
" 20 "	3.00	.360	1.820	2.180	
" 25 "	3.75	.450	2.275	2.725	
" 30 "	4.50	.540	2.730	3.270	
" 35 "	5.25	.630	3.185	3.815	
" 40 "	6.00	.720	3.640	4.360	
Sugar beet leaves, 1 lb	.12	.017	.051	.068	
" " 5 lbs.....	.60	.085	.255	.340	
" " 15 "	1.80	.255	.765	1.020	
" " 20 "	2.40	.340	1.020	1.360	
" " 25 "	3.00	.425	1.275	1.700	

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Sugar beet leaves, 30 lbs..	3.60	.510	1.530	2.040	
" " 35 " ..	4.20	.595	1.785	2.380	
" " 40 " ..	4.80	.680	2.040	2.720	
Sugar beet pulp, 1 lb.....	.10	.006	.073	.079	1:12
" " 5 lbs ..	.50	.030	.365	.395	
" " 15 "	1.50	.090	1.095	1.185	
" " 20 "	2.00	.120	1.460	1.580	
" " 25 "	5.20	.150	1.825	1.975	
" " 30 "	3.00	.180	2.190	2.370	
" " 35 "	3.50	.210	2.555	2.765	
" " 40 "	4.00	.240	2.920	2.160	
Beet molasses, 1 lb.........	.79	.091	.595	.686	1:6.5
" " 2 lbs.......	1.58	.182	1.190	1.372	
" " 3 "	2.37	.273	1.785	2 058	
" " 4 "	3.16	.364	2.380	2.744	
" " 5 "	3.95	.455	2.975	3.430	
" " 6 "	4.74	.546	3.570	4.116	
" " 7 "	5.53	.637	4.165	4.802	
" " 8 "	6.32	.728	4.760	5.488	
" " 9 "	7.11	.819	5.355	6.174	
Apple pomace, 1 lb. *.....	.233	.011	.164	.175	1:14.9
" " 5 lbs......	1.165	.055	.820	.875	
" " 15 "	3.495	.165	2.460	2.625	
" " 20 "	4.660	.220	3.280	3.500	
" " 25 "	5.825	.275	4.100	4.375	
" " 30 "	6.990	.330	4.920	5.250	
" " 35 "	8.155	.385	5.740	6.125	
" " 40 "	9.320	.440	6.560	7.000	
Skim milk gravity, 1 lb...	.096	.031	.065	.096	1:2.1
" " 5 lbs .	.480	.155	.325	.480	
" " 8 " ..	.768	.248	.520	.768	
" " 12 " ..	1.152	.372	.780	1.152	
" " 15 " ..	1.440	.465	.975	1.440	
" " 20 " ..	1.920	.620	1.300	1.920	
" " 25 " ..	2.400	.775	1.625	2.400	
" " 30 " ..	2.880	.930	1.950	2 880	
Skim milk centrifugal, 1 lb.	.094	.029	.059	.088	1.2
" " 5 lbs.	.470	.145	.295	.440	
" " 8 "	.752	.232	.472	.704	
" " 12 "	1.128	.348	.708	1.056	
" " 15 "	1.410	.435	.885	1.320	
" " 20 "	1.880	.580	1.180	1.760	

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* From Bulletin of Information No. 1. Penna. State College.

TABLE II.—*Continued.*

Kind and amount of feed.	Total dry matter.	Pounds of digestible nutrients.			Nutritive ratio.
		Protein.	Carbohydrates + (fat × 2.25).	Total.	
Skim milk centrifugal, 25 lbs.	2.350	.725	1.475	2.200	
" " 30 "	2.820	.870	1.770	2.620	
Buttermilk, 1 lb.	.10	.039	.065	.104	1:1.7
" 5 lbs.	.50	.195	.325	.520	
" 8 "	.80	.312	.520	.832	
" 12 "	1.20	.468	.780	1.248	
" 15 "	1.50	.585	.975	1.560	
" 20 "	2.00	.780	1.300	2.080	
" 25 "	2.50	.975	1.625	2.600	
" 30 "	3.00	1.170	1.950	3.120	

To illustrate how these tables may be used, we will examine a system of feeding which the writer observed the present season in a certain section of the state, and was told was quite extensively practiced. The section referred to is devoted almost exclusively to dairying, and timothy hay constitutes the greater portion of the coarse fodder during the feeding season. Oats are about the only grain grown. Corn is purchased and ground with the oats, in about equal weights, to make "chop" which is fed with the hay. The cows will not greatly vary from 1000 lbs. live weight. While these cows are in full flow of milk in the spring before pasture is ready, they are fed about 20 pounds of hay and 8 pounds of chop per day. Turning to the tables we find that 20 pounds of hay, 4 pounds of oats and 4 pounds of corn contain digestible nutrients as follows :—

	Dry matter.	Protein.	C. H. and Fat.	Total.	Nutritive Ratio.
20 lbs. hay	17.40	.560	9.300	9.860	
4 lbs. oats	3.56	.368	2.772	2.640	
4 lbs. corn	3.56	.316	3.056	3.372	
Total	24.52	1.244	14.628	15.872	1:11.7
Wolff's Standard	24.00	2.5	13.4	15.9	1: 5.4

Upon comparison of the nutrients furnished by this ration with Wolff's standard as given in table I, it is discovered that while the dry matter and total nutrients are not far out of the way, the protein is much too small, the carbohydrates and fat are somewhat too great, while the nutritive ratio is far too wide.

This result might readily have been foreseen had we paused a moment to note the nutritive ratio of each of the three foods entering into the ration. They are, timothy hay, 1:16.6; oats, 1:6.2; corn, 1:9.7. Neither of them is as narrow as the standard, and it is impossible to combine them into a ration that is approximately balanced. As corn is a purchased product the natural suggestion is that the corn should be replaced by some food having a high proportion of protein, or in other words, a very narrow nutritive ratio. Consulting the table, it is found that among such are linseed meal, cotton-seed meal, gluten feed, malt sprouts, buckwheat, middlings, etc. As buckwheat middlings is a N. Y. State product and can readily be put in stock during the winter, it is suggested to substitute it for the corn in the ration. Again taking the figures from the table we have :—

	Dry matter.	Protein.	C. H. and Fat.	Total.
20 lbs. timothy hay......	17.40	.560	9.300	9.860
4 lbs. oats...............	3.56	.368	2.272	2.640
4 lbs. buckwheat mid's.	3.48	.880	1.824	2.704
Total.............	24.44	1.808	13.396	15.204

Nutritive ratio 1:7.4

While this ration is much improved over the previous one and will produce a much freer flow of milk it is still too wide to produce the best results.

If the timothy hay is reduced two pounds, and two pounds of cotten-seed meal put in its place we get:—

	Dry matter.	Protein.	C. H. and Fat.	Total.
18 lbs. timothy hay......	15.66	.504	8.370	8.874
4 lbs. oats.............	3.56	.368	2.272	2.640
4 lbs. buckwheat mids..	3.48	.880	1.824	2.704
2 lbs. cotton seed meal..	1.84	.744	.888	1.632
Total.............	24.54	2.496	13.354	15.850

Nutritive ratio 1:5.3

This ration corresponds very closely to the standard and while the purchase of the cotton-seed meal will add somewhat to the expense still it is the experience of careful feeders that the increased production will abundantly pay for thus securing a proper balance to the ration.

The same result may be obtained by using other feeding stuffs having a narrow nutritive ratio. The question is likely to be raised, which of the various feeding stuffs offered in the market may most economically be used in supplementing the home grown foods to produce a balanced ration? This question is best answered by formulating properly balanced rations containing each of the foods under consideration, and by assigning the actual market value per pound to each of the constituents of the ration, its cost is readily ascertained and the cheapest may be selected.

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40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N.Y., 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western N. Y., 27 pp.
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151. Gravity or Dilution Separators.
152. Studies in Milk Secretion.
153. Impressions of Fruit-Growing Industries.
154. Table for Computing Rations for Farm Animals.

Bulletin 155. **December, 1898.**

Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

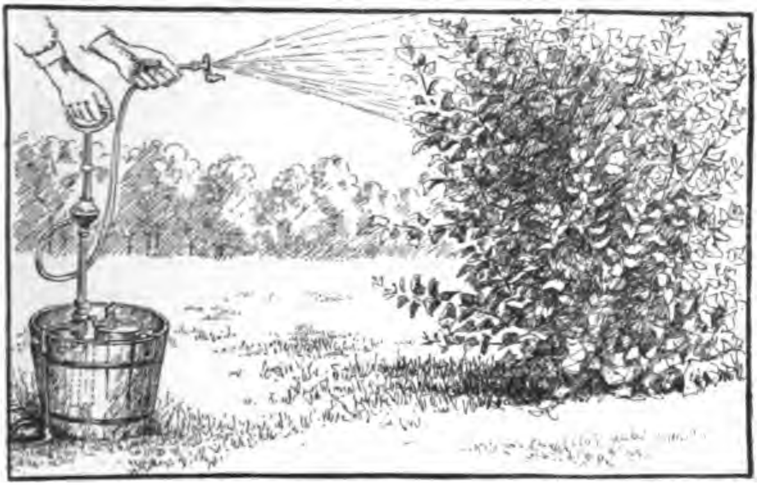
HORTICULTURAL DIVISION.

SECOND REPORT ON THE

SAN JOSÉ SCALE

WITH REMARKS ON

THE EFFECTS OF KEROSENE ON FOLIAGE.



By H. P. GOULD.

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CORNELL UNIVERSITY, ITHACA, NOV. 15, 1898.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir:—In 1897, careful experiments were made by H. P. Gould upon methods of treating the San José scale in summer time, and the results were published in Bulletin 144 (January, 1898). It was found that a mechanical mixture of kerosene and water, 1 part of the oil to 4 parts of water, will kill the scale and not injure foliage of the plants with which we have experimented. In 1898, Mr. Gould continued the experiments, and the results, published herewith, confirm the conclusions of last year. The oil and water are mixed automatically by an attachment to the pump (see picture on title.) We are now convinced that valuable plants can be saved from an attack of the San José scale by summer treatment. However, we believe that the effort to save plants should be allowed only on stock which is permanently planted in the grounds of responsible parties, and not on stock which is to be sold.

These experiments have been made under the direction and supervision of Professor Bailey. Mr. Gould is now one of the State inspectors of nursery stock.

The report is now submitted for publication as a bulletin under Chapter 67 of the Laws of 1898.

I. P. ROBERTS,
Director.

INSPECTION LAWS.

The San José scale has been the cause of much legistative action, fifteen States having passed laws which provide forthe inspection of nursery stock and other trees, shrubs, etc., where this and other dangerously injurious insect pests and fungous diseases are likely to be found.

The States having such laws are the following: California, Colorado Delaware, Georgia, Iowa, Kentucky, Maryland, Michigan, New Jersey NewYork, North Carolina, Oregon, Pennsylvania, Virginia and Washington

From the fact that the San José scale has become so widely distributed in the eastern States, its appearance in new and unsuspected localities may occur at almost any time, notwithstanding the existence of rigid laws and the vigilance of nursery and orchard inspectors. These inspectors are necessary means to the desired end, but it is only when the most hearty co-öperation exists on the part of the people who are concerned that the object and aim of such laws can be fully accomplished.

As a further caution, parties purchasing nursery stock should ask for certificate of inspection, accompanying the stock when it is delivered.

The New York law is for the "prevention of disease in fruit trees and the extirpation of insect pests that infect the same." It specifics yellows black knot and San José scale. Every infested plant is held to be a public nuisance. Persons suspecting the presence of serious diseases of fruits may apply to the commissioner of agriculture for an inspection. "Unless previously inspected by a federal officer the same year," the commissioner o agriculture shall "cause an examination to be made at least once each yea prior to September first of each and every nursery or other place where trees shrubs or plants, commonly known as nursery stock, are grown for sale," and if the stock is found to be healthy there shall be issued to the proprieto "a certificate setting forth the fact of the examination and that the stock s examined is apparently free from any and all such disease or diseases, pes or pests." Infested stock may be destroyed.

I. NOTES ON THE SAN JOSÉ SCALE.

Another season's experience has again demonstrated that the San José scale can be as easily controlled as many of the insects with which the farmer and fruit-grower are more familiar. The potato-bug has been fought for twenty years, the codlin-moth has been given annual treatments of Paris green ever since the general spraying of orchards has been practiced, yet these insects reappear in abundance every year. They and their kindred, however, cause no alarm ; but if they were left unchecked in their ravages, the annual losses from them in this State would be almost inconceivable.

It may not be possible, from a practical point of view, to exterminate the scale in an infested orchard without injury to the trees any more than it is possible to exterminate the potato-bug ; yet I am convinced that the same vigilant, persistent effort which controls the potato-bug, codlin-moth and other insect pests will also control the San José scale. I do not wish to minimize the danger from this insect, for it is indeed serious under conditions favorable for its development, but there has been a tendency to unduly emphasize the seriousness of the pest.

Our observations on this insect, recorded in Bulletin 144, have been continued and extended during the past season, and the conclusions at which we arrived from last season's experience have been largely corroborated.

EXPERIMENTS IN 1898.

A large number of small pear trees, badly infested with the San José scale, were placed at our disposal and treated with the following solutions and mixtures :

Lot No. 1. Whale-oil soap, 2 pounds to a gallon of water.
Lot No. 2. Whale-oil soap, 1 pound to a gallon of water.
Lot No. 3. Pure kerosene.
Lot No. 4. Kerosene, 20 per cent ; water, 80 per cent.
Lot No. 5. Kerosene, 10 per cent ; water, 90 per cent.

Lot No. 6. Kerosene, 7 per cent; water, 93 per cent.
Lot No. 7. Quassaine, ¼ lb. to 1 qt. water.
Lot No. 8. West's Insecticide, ½ pt. to 1 gallon of water.

The first application was made June 16. The weather was clear, with no wind. Young insects had just begun to appear, a small number being found on nearly every infested tree. The second application was July 1. The weather was clear, very hot and no wind on this latter date.

The following notes were taken on the results of the first application: Mixtures No. 3 and 4 seem to be the only ones which have had much effect. On the trees thus treated, there are very few young insects to be found, indicating that nearly all of the mature insects have been killed by the first applications of clear kerosene and the mixture of 20 per cent kerosene and 80 per cent water. There are apparently as many young insects on all trees sprayed with the other solutions and mixtures as there are on the trees which have not been sprayed. The presence of so many young insects on these trees would seem to indicate that the materials used had not been effective in destroying the mature insects. It should be stated in this connection, however, that the physical condition of the whale-oil soap used at the time of the first application, was not satisfactory.*

The third and last application was made July 19. The weather was cloudy and very "muggy." At the time of making this application, the following conditions, results of the first two applications, were noted:

No. 1. Foliage slightly injured; trees practically free from young insects.
No. 2. Foliage slightly injured; a few young insects found.
No. 3. About 10 per cent of foliage injured; insects apparently all killed.
No. 4. Practically no injury to foliage; no young insects to be found.
No. 5. Foliage uninjured; young insects numerous.
No. 6. Foliage uninjured; young insects numerous.
No. 7. 50 per cent of foliage injured; young insects numerous, but mature ones show some effect of treatment.
No. 8. 75 per cent of foliage injured; but few young insects alive.

Results of sprays.—It was intended after the application on July 19, to allow the trees under experiment to remain undisturbed for the remainder of the season and so watch the ultimate results of the applications, but owing to circumstances it became necessary to make the final records about the middle of August, as follows :

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*The whale-oil soap solutions in Nos. 1 and 2 were applied with a brush and this fact doubtless accounts for the slight injury to the foliage. Only small quantities of the solution came in contact with the leaves. The soap solution used at this time, instead of being of uniform consistency, was of a granular nature: that is, there seemed to be a very thin liquid (probably water) in which was a coarse precipitate. In this condition it was impossible to apply it thoroughly, even with a brush. As this difficulty had not been experienced before in using other lots of the same brand of soap, I wrote to the manufacturers in regard to it. In their reply they suggested that better results might be obtained if the soap were dissolved in moderately hot water and agitated while cooling. This caution was followed in preparing the soap used in later applications, and none of the earlier difficulty was experienced.

No. 1. Insects apparently all dead.
No. 2. A few insects alive.
No. 3. Insects apparently all dead.
No. 4. Insects apparently all dead.
No. 5. Insects apparently all dead.
No. 6. A few insects alive.
No. 7. A few insects alive.
No. 8. Insects apparently all dead.

The condition of the foliage on all the trees remained essentially the same as it was on July 19, when the notes recorded above were taken.

Effects of whale-oil soap.—In the light of these experiments, several facts are conspicuous. It will be noted that the first application of whale-oil soap had little effect on the scale. From the results of the later applications, it is evident that the ineffectiveness was due in part, if not entirely, to the poor physical condition of the soap solution. In the final examination of the trees treated with whale-oil soap, the fact was again emphasized that a solution weaker than two pounds to a gallon of water cannot be relied upon to kill the scale.

Effects of kerosene.—Four different strengths of kerosene were used in these experiments : pure, 20 per cent, 10 per cent and 7 per cent. The pure kerosene was the only strength which injured the foliage to any appreciable extent, and in this case the injury was not sufficient to interfere with the normal activities of the trees. From the fact, however, that a 20 per cent mixture of kerosene and water gave equally as good results as clear kerosene in killing the scale, there seems to be no reason for using a stronger mixture than this. This mixture (20 per cent,) has in no case, under my observation, injured the foliage.

The mixtures containing the smaller percentages of kerosene were less satisfactory, though the final results of the 10 per cent mixture indicate that good returns may result from the use of this strength. A 7 per cent mixture, or 1 to 15, is evidently too weak to be effective, as live scales were found on the trees so treated during all the time they were under observation.

The kerosene and water mixtures were applied by means of a pump having a kerosene attachment, thus using the ingredients in the form of a mechanical mixture. Several pumps of this type are now on the market.

As a further suggestion as to the use of pure kerosene, a word of caution may be given. While no serious results followed the use of it in the cases above noted, very conflicting results have been obtained by different experimenters, and by the same experimenters at different times. In many cases no apparent harm has followed its use, while in others, for no obvious

reason, the trees have been killed. Probably the best time to use kerosene in any strength is on a bright sunny day when the conditions favor a rapid evaporation of the kerosene. Pure kerosene should not be used without an appreciation of the fact that the results may prove fatal to the plants treated with it.

Of the different solutions and mixtures used in this series of experiments, it is evident that, all things considered, No. 4 or 20 per cent kerosene and 80 per cent water, is the most satisfactory. While this was fully effective in destroying the scales, the foliage remained in good condition. This result corroborates our experience (in Bulletin 144) of last year. Some of the stock which was treated with the 20 per cent mixture was examined by Mr. Slingerland, who pronounced all the scales to be dead.

CONCLUSIONS FROM OUR EXPERIENCE.

Practicability of spraying.—The practicability of spraying for San José scale will depend entirely upon conditions. In the case of fruit trees or ornamentals, permanently set, which have not already become weakened from the effects of the scale, it would seem, in the light of the evidence at hand, to be an entirely feasible operation and if thoroughly done, there can be little doubt as to its effectiveness; but spraying cannot be recommended for nursery stock. When the trees are so close together as they are in the nursery, it is impossible to spray with sufficient thoroughness to insure complete success, and the possibility of distributing the scale on trees thus sprayed becomes too great to warrant such a method of treatment.

When to spray.—From the fact that the scales are probably more susceptible to the action of insecticides during the period of activity than they are during the winter months, it follows that a weaker insecticide can be used in the summer than during the winter; and so far as the use of kerosene is concerned, the evidence at hand seems to show that plant life is little, if any, more liable to injury from it when in an active state of growth than when dormant. Accordingly, the summer season would seem to be the preferable time to spray if kerosene in any form or strength be used. Professor J. B. Smith recommends the use of pure kerosene during the middle of a clear sunshiny day in September. In our own experience we have obtained satisfactory results by using kerosene in the spring or early summer as soon as the young insects began to appear.

In using whale-oil soap, the nature of the case demands that it be applied only when the plants to be treated are dormant. Since it must be used at the rate of two pounds to a gallon of water in order to destroy the scale, and at this strength it is destructive to the foliage, a summer treatment with whale-oil soap is out of the question unless it be applied only to the trunks and larger limbs of infested trees and shrubs.

FUMIGATING.

As a method of treating infested nursery stock, fumigating with hydrocyanic acid gas is doubtless the most satisfactory and effective treatment which has been extensively used. The value of this treatment was recognized in California some years ago, but for various reasons it has not been generally used in the East. However, there seems to be no adequate reason why it should not prove as effective here as in the West. Probably the most extensive use of the gas treatment in the eastern States has been in the experiments of Johnson, of Maryland. In his recent report* there is detailed a long list of experiments in which is seemingly proved the adaptability of this method of treatment for eastern as well as for western conditions. The most of Johnson's work, however, was in bearing orchards where tents were used for covering the trees during treatment.

The chemicals used by him in giving the gas treatment are approximately as follows:

Fused cyanide of potassium, 98 per cent pure...	1 oz. by weight
Sulfuric acid	1¼ oz. by measure
Water	2 oz. by measure

The above quantities of material are sufficient for 100 cubic feet of space.

In fumigating nursery stock in small quantities, a large box which can be made perfectly air-tight is convenient. The stock is first placed in the box, then an earthen or glass vessel placed near the center of the box, the cubical contents of which has been previously estimated. The chemicals are then weighed out in proportion to the size of the box, the above mentioned amounts being used for every hundred cubic feet of contents. The sulfuric acid should be put in the vessel, the water added, and last of all the cyanide is dropped in. If the latter is carried in a paper bag, the bag may also be dropped into the diluted sulfuric acid, and in this way the danger of handling is somewhat reduced. As soon as the cyanide is put in the acid, the box should be quickly closed and the stock allowed to remain at least thirty minutes.

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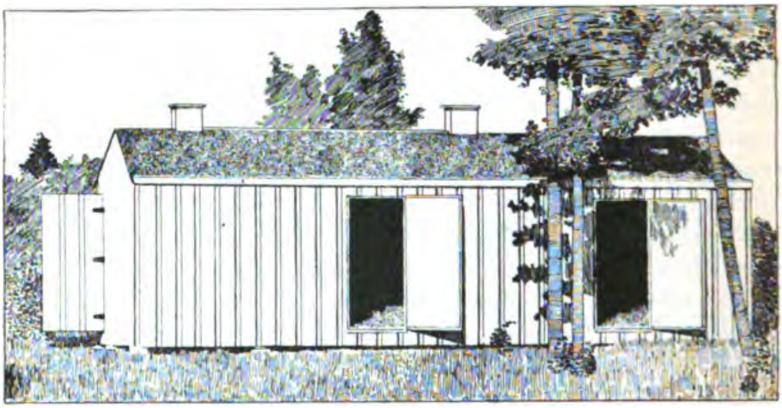
*Bulletin 57, Maryland Experiment Station.



8. *Fumigating house. Adapted from Johnson.*

When large amounts of nursery stock are to be fumigated, a small building specially constructed for the purpose will be more satisfactory. Such buildings are in common use in Maryland, where all stock handled by nurserymen is required by law to be given the gas treatment.

A fumigating house.—A building similar to the one in question is illustrated by Johnson and described as follows : "It is 32x16x8 feet with a roof pitch of two feet, and is divided into two rooms about 15x14x7 feet and two smaller rooms 4x5x7 feet constructed as follows :

"First, a good substantial frame is built which is covered outside with 1¼ inch 12 inch Virginia pine boards, and ½x4 inch batting. The interior is first lined with two-ply cyclone paper and then with 4 inch flooring. The partitions and floors are also double with paper between. The roof is covered with heavy roofing paper, tarred and graveled. The doors are 6½ x3 feet (3½ would be better), made double, refrigerater style, and hung with three heavy strap-iron hinges, and held in place when closed with two bolts. At the top of each large room on the opposite side there is a door 3x2½ feet for ventilating purposes. There is also a flue opening between the rooms as shown in the illustration, which can be uncapped when it is desired to air the house." (See Fig. 7.)

Johnson estimates that a house the size of the one described is large enough for parties handling a million or more trees annually.

The advantage of having a double house or room with a partion in it lies in the fact that when there are large quantities of stock to be fumigated, one side or one room can be filled while the treatment, which should continue for at least a half hour, is being applied to the other, thus greatly facilitating the work.

In using such a house as this, one would proceed in essentially the same manner as described for using a fumigating box. After the doors have been opened, following a fumigation, the house should be allowed to air for at least ten minutes before an attendant attempts to enter.

Caution.—In handling sulfuric acid and cyanide of potassium, all possible care must be taken. The former will destroy clothing if it comes in contact with it, and wounds caused by it are very painful and slow to heal. *The cyanide of potassium is one of the most deadly known poisons.* After the fumigating box or house is opened after being used, it should be very thoroughly aired before the attendants approach near enough to inhale any of the gas, as serious results will follow if this precaution is not taken. As cyanide of potassium will absorb moisture if exposed to the air, it should be kept in tightly closed jars or cans.

Conclusion.—In the work of Johnson, this method of treating bearing trees has been proved to be of practical importance when properly managed. In such operations, the trees are covered during treatment by tents constructed for the purpose, and where one has a large number of infested trees, it may be more satisfactory, in the end, to have such tents made and apply this treatment rather than to spray.

SUMMARY.

1. With the exception of the pure kerosene and the 20 per cent mixture, the first applications of the various insecticides seemed to be mostly ineffective. The poor physical condition of the whale-oil soap solution may account for its not being more satisfactory.

2. In the final results, live scales were found on trees treated with whale-oil soap, one and one-half pounds to a gallon of water; a 1 to 15 mixture of kerosene and water; and quassaine. The insects on all the trees treated with the other materials seemed to be killed but with various effects on the foliage.

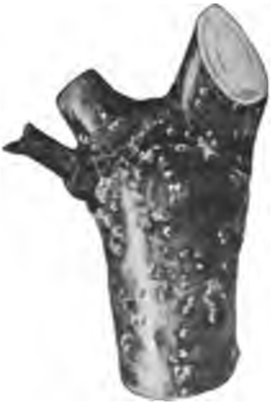
3. A solution of whale-oil soap weaker than two pounds to a gallon of water cannot be relied on to kill the scale.

4. Of the different kerosene mixtures, the 20 per cent or 1 to 4 mixture gave the most satisfactory results. A 10 per cent mixture may be effective but should not be relied on for the best results.

5. The practicability of spraying for the San José scale is dependent upon conditions. Nursery stock, if badly infested, should usually be burned.

6. Probably the most satisfactory time to spray for the scale is during its active stage; that is, during the summer and early fall months.

7. Fumigating with hydrocyanic acid gas may doubtless be used successfully in many cases.



9. *San José scale, natural size.*

10. *Oyster-shell bark-louse. Nat. size. Often mistaken for the scale.*

8. A building made especially for the purpose is convenient if large quantities of nursery stock are to be treated.

9. As potassium cyanide is a most deadly poison, also the gas generated in fumigating, great care must be taken in using and handling it. Air the room thoroughly before entering it.

II. EFFECTS OF KEROSENE ON PEACH AND APPLE TREES.

Although the value of kerosene in combating sucking insects was recognized in the early history of spraying, yet it is only within the past few years that it has been used to any extent in any other form than as an emulsion with soap. But with the advent of the San José scale in such force in the East, experimenters began to turn their attention to kerosene in other forms, and as a result many references to the effects of kerosene have appeared in horticultural literature during the past few years. And yet there is much to learn concerning kerosene and its effects on plant life. From the fact that the results have been so conflicting without any apparent reason, the use of kerosene is an uncertain practice. It is generally conceded by those who have had much experience that the conditions of the weather have a marked influence in determining its effects; that if applied in bright sunny weather,—a condition which favors the rapid evaporation of the oil,—the liability to injury is greatly reduced in comparison with applications made in cloudy weather.

With respect to the effect of the 20 per cent mixture of kerosene with water on the buds of Cornus and Pyrus referred to in Bulletin 144, it may be said that they did not suffer in the least. The trees and shrubs sprayed with this strength of kerosene, a year ago, made an excellent growth the past season and are now in good condition. Several months after the Cornus bushes were sprayed, the bark, in some instances, indicated some injury, but it has not proved to be of a serious nature. I think this injury might have been avoided if the climatic conditions had been regarded when the spraying was done.

It was with the hope of throwing some light on the effects of kerosene and of determining under what conditions it is possible to use it with impunity that a series of experiments was begun during the winter of 1897–8. The trees used for this work were young peaches and apples.

Kerosene in four strengths was used ; pure, 50, 40 and 20 per cent.

The first series of trees was sprayed February 7, and others March 7, April 13, May 3 ; and the final notes were made May 20 and July 8. The character of the weather was carefully noted at each treatment. In applying the kerosene to the trees, a Stott's nozzle, which makes a very fine spray, was used, and while the trees were thoroughly sprayed, care was taken not to apply more of the various strengths of kerosene than was required to thoroughly moisten the surfaces.

It is not necessary to repeat all the details of the experiment, but to give only the summary conclusions.

From the results of the experiment, it was evident that kerosene should be used with caution, especially on peach trees. While in no case were any apple trees greatly injured, several peaches suffered very serious injury. Any mixture of kerosene stronger than 20 per cent, applied to peach trees, even when dormant, is likely to affect the tree injuriously. In some cases under observation, it was noted that a 50 per cent mixture was more disastrous than when used undiluted.

It seems probable that clear kerosene may be used on apple trees without serious results, although it is not unlikely that trees so treated are in some instances more or less weakened. Any strengths weaker than 50 per cent seem to have little, if any, injurious effect on apple trees.

Again, in the light of the data at hand, the commonly accepted notion that kerosene applied on a cloudy day is more likely to injure the plant than if applied on a clear sunshiny day, is corrobrated. With only one exception in the case at hand, did this result otherwise.

It is not unlikely that the manner in which the kerosene is applied may have material effect upon the results. If the spray is coarse, so that in applying it the trees become drenched with oil and it forms in drops on the tips of the leaves, the danger is doubtless much greater than when a very fine spray is used and the foliage and branches are merely moistened. In the latter case the evaporation is rapid, and this seems to be one of the essential features in avoiding the injurious effects of kerosene.

The results of our experience in the use of kerosene are not unlike those of others. Experimenters have recorded very conflicting results in their experience with pure oil, in some instances very little harm coming from its use, while in other and similar cases, without apparent cause or reason, very serious results have occurred.

Why such conflicting results should occur is difficult to explain, but it seems not unlikely that it may be due to the individual variation of the trees or plants treated.

From our study of the subject we draw the following

SUMMARY.

1. Pure kerosene is likely to seriously injure peach trees even when they are perfectly dormant.

2. A 20 per cent mixture of kerosene can probably be safely used on the peach at any time, but a stronger mixture cannot always be so applied.

3. Apple trees do not appear to be as susceptible to the action of kerosene as peaches. In some instances clear kerosene did not harm them.

4. There seems to be little, if any danger, to apple trees from a mixture containing 50 per cent or less of kerosene.

5. Very conflicting results are often obtained from the use of kerosene.

6. Kerosene is especially likely to cause injury if applied on other than a bright sunny day.

7. In our experience, a 20 per cent solution (1 part oil to 4 parts water) is harmless to plants and destructive to insects, even to the San José scale.

H. P. GOULD.

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Bulletin 156. **December, 1898.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

AGRICULTURAL DIVISION.

Third Report on Potato Culture.

By I. P. ROBERTS and L. A. CLINTON.

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THIRD REPORT ON POTATO CULTURE.

CONCLUSIONS BASED UPON EXPERIMENTS IN POTATO CULTURE DURING FOUR YEARS.

1. The average yield of potatoes throughout the state is not more than one-half what it should be and what it would be were better methods practiced.

2. All soils of ordinary fertility contain sufficient potential plant food to produce abundant crops. By tillage, and drainage if necessary, a part of this potential plant food can be made available for the use of plants.

3. Early planting of potatoes and frequent tillage to conserve moisture will ordinarily give best results.

4. Early planting necessitates vigorous spraying with Bordeaux mixture and Paris green to protect the foliage from blight and beetles.

5. Success with potatoes depends largely upon the preparation given the soil before the potatoes are planted. Plowing should be deep, and at the time of planting, soil should be mellow and loose.

6. On soils which are likely to be affected seriously by droughts, it is especially important that the potatoes be planted early and deep and the tillage should be frequent and level.

7. On soils which are not well drained, either naturally or artificially, and on clay or clay loam soils, potatoes may be planted somewhat shallow and slight hilling may be practiced with benefit.

8. Harrowing the land after the potatoes were planted and before the plants appeared produced marked beneficial results.

9. From six to seven cultivations have given best yields.

POTATO EXPERIMENTS IN 1898.

For four years the experiments with potatoes have been continued. In 1895 an experiment was planned, the object of which was to determine something of the possibilities of the soil when superior methods of tillage were practiced. A study of the statistics of crop production in New York and other states revealed the fact that something was radically wrong with the soil or with the methods being pursued. The average yield of the ordinary farm crops had fallen so low that in many cases actual loss resulted in their production. This condition prevailing while the soil was yet comparatively new, led to the belief that tillage was being neglected. The experiments were planned to learn what could be accomplished by superior tillage and care. The results of these experiments for previous years have been recorded in bulletins 130 and 140 of this station. While the results for 1898 do not differ materially from the results heretofore secured, yet it seems wise to publish the same.

Details of experiment.—The land selected for the experiment was a portion of the series of plats upon which the experiments had been conducted in previous years. The soil is gravelly and porous and especially subject to injurious effects from droughts. The potato crop grown this year is the fifth crop removed from the land since any fertilizer or manure has been applied. The soil is beginning to show a deficiency of humus owing to the intensive culture which has been given and the slight returns of organic matter. While cover crops of crimson clover, wheat or rye have been used, yet necessarily the growth has been restricted and the amount available to plow under in the spring has been small. The result of this deficiency of humus is shown in the tendency of the soil to become hard and compact under the effects of beating rains. In order to keep a soil permanently in good physical condition, it is absolutely necessary that organic matter be returned in some way either by green manuring or the use of barn manures.

Previous treatment of the soil.—The plats entering into the experiment have been cropped heavily for five years since any manures were applied with the exceptions noted below. In the winter of 1893–4, about ten tons of mixed barn manure were applied per acre. In 1894 all plats were planted to corn which was one of the regular crops in the four years rotation. Previous to 1894 the rotation which had been practiced was

1. Wheat.
2. Clover and timothy.
3. Corn.
4. Oats.

The crops which have been produced upon each plat since and including 1894 are shown by the accompanying table :

Plat No.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.
Crop of 1894	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn
Crop of 1895	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Used for roadway	Potatoes	Corn	Corn
Crop of 1896	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Corn	Potatoes fertilized	Potatoes fertilized	Potatoes	Potatoes
Crop of 1897	Oats	Oats	Oats	Oats	Oats and peas	Oats and barley	Peas	Barley	Barley	Oats	Oats	Oats and peas
Crop of 1898	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes	Potatoes

While it will be seen that all plats have not received the same treatment each year, yet the various plats can be compared with reference to their previous treatment.

In all cases after the crop was removed the land was plowed and seeded either to crimson clover, or rye, or wheat which was allowed to serve as a cover crop during the winter and was plowed under in the spring. Thus the land has been thoroughly plowed from two to three times each year.

Record of the potato crop for 1898.—In the spring, as early as the conditions of the soil would permit, the land was plowed to a depth of about ten inches. Shortly before the time for planting, the land was replowed with the gang plow, the furrow being turned to a depth of about four inches. The harrow was then used and the surface thoroughly pulverized and fined. Rows were marked off at a distance of 40 inches apart and the furrows for the potatoes were opened with a common shovel plow to a depth of about five inches.

The "seed" was from first-class stock, only large, marketable potatoes being used. These were cut into pieces containing from one to three eyes, about two strong eyes to the piece being what was desired. The pieces were dropped in the furrows directly after the furrows had been opened, one piece being put in a place and at distances fourteen inches apart in the row. The shovel plow was again used and a furrow was opened in the middle of the space left when the first furrows were opened. This second use of the shovel plow served to cover the potatoes, the earth being ridged up directly over the potato row. (See frontispiece which is from photograph). The planting was done on May 10. The soil was then left undisturbed until May 28. The ridges which were left over the seed potatoes covered them to a depth of about eight inches. By May 28 the weed seeds which were in the surface soil had germinated and the whole surface was covered with tiny weeds. A spike tooth hrrrow was fitted with a piece of 2x4 scantling placed diagonally across underneath the frame and held in place by the harrow teeth. The harrow thus rigged was used upon the potato plats, being first run lengthwise of the rows and then crosswise. The weight of the driver upon the harrow was necessary in order to make it do the leveling as required. The benefit derived from this treatment was very marked. All weeds were destroyed, the surface crust was broken, all clods and stones were removed from above the row and deposited in the center of the space between rows, the surface was leveled and in every way the conditions were made favorable for the rapid growth of the potatoes, and they appeared above ground in three or four days.

The treatment which the various plats received during the season and the yield from each plat is shown by the following tabular statement.

RECORDS OF POTATO PLATS, 1898.

Plat No.	Date planted.	Variety of potatoes.	No. of cultures.	No. of spraying.	Date of digging.	Yield per plat. Pounds.	Yield per acre. Bushels.
21	May 10	Endurance.	6 level	7	Oct. 18	1,196	398.6
22	"	Carman No. 3.	6 "	7	" 18	1,034.5	344.8
23	"	" "	3 "	7	" 18	910	303.3
24	"	" "	3 "	7	" 17	1,020	340
25	"	" "	3 hilled	7	" 17	982.5	327.5
26	"	" "	6 level	7	Sept. 29	931.5	310.5
27	"	" "	3 "	7	" 29	809	269.6
28	"	" "	3 "	7	" 29	809.5	269.8
29	"	" "	6 "	7	" 29	610	213.3
30	"	" "	6 "	0	" 29	618.5	206.1
31	"	Rose of Sharon	6 "	7	" 29	356	118.6
32	"	Endurance.	6 "	0	" 29	696	232

Spraying operations.—Early in the growth of the potatoes spraying became necessary. In addition to the Colorado potato beetle (Doryphora decemlineata), the leaf-flee-beetle (Crepidodera cucumeris) early began its depredations. Bordeaux mixture and Paris green used freely served to check both insects. Several farmers have informed us that the Bordeaux mixture has failed with them to check the work of the leaf-flee-beetles, but with us for three years in succession it has proven effective in checking, although it has not entirely driven them away. Bordeaux mixture made and tested with the ferrocyanide of potassium proved very satisfactory.

Directions for making Bordeaux mixture.—Directions were given in Bulletin 140 for making Bordeaux mixture. We have found that the ferrocyanide of potassium test is much simpler and so the following directions are given:

Into a barrel of water suspend a gunny sack or other porous bag, containing two pounds of copper sulfate for every gallon of water in the barrel. If this is suspended near the surface of the water at night it will all be in solution by morning and ready for use. Into a water tight box or other open receptacle place some fresh burned caustic lime, the amount to be determined somewhat by the amount of spraying to be done, but from 40 to 50 pounds of lime can be easily slaked at one time. Add sufficient water to thoroughly slake all the lime and keep well stirred so that the water may come in contact with all particles. This thorough stirring is important and the lime should be carefully watched and stirred for several minutes or otherwise it is likely to become dry and hard. After the lime is all slaked, cover it over with water and it is then ready for use and may be kept for any length of time desired if it is always kept covered with water. Ferrocyanide of potassium may be purchased from the drug store, and comes as a solid. One ounce of ferrocyanide of potassium dissolved in one ounce of water will be sufficient for testing many barrels of the Bordeaux mixture. When it is desired to begin spraying, there should be provided two empty barrels. Into one barrel dip three gallons of the copper sulfate solution after it has been *thoroughly* stirred. This will provide the six pounds of copper sulfate in case two pounds were dissolved per gallon of water and will be sufficient for making one barrel, or 45 gallons of Bordeaux mixture. Dilute the three gallons with ten or more gallons of water.

From the lime box dip from five to ten pounds of slaked lime into the empty barrel. Add water and stir thoroughly until the milk of lime is produced, after which dilute with some ten gallons more of water. Pour the milk of lime thus diluted through a sieve into the dilute copper sulfate solution. The quantity of lime to be added to the copper sulfate is to be determined by the ferrocyanide of potassium test. After adding a small amount of the milk of lime to the copper sulfate solution, add to the mixture a drop of ferrocyanide of potassium. If a brick red color is produced where the drop strikes, it indicates that more lime is needed. Continue adding the milk of lime until no reddish color will be produced when the ferrocyanide of potassium is used. A few trials will enable one to judge very accurately as to the amount of lime required. A little surplus lime will do no harm.

If Paris green is to be used it should now be added. Take 4 ounces of Paris green and place it in a dish and add water just sufficient to make a paste, and stir thoroughly until a homogeneous mixture is formed. Pour this paste into the mixture of lime and copper sulfate and stir vigorously.

Pour the lime and copper sulfate mixture into the spray barrel, which should have a capacity of 45 to 50 gallons, and fill the barrel with water. If there is no agitator in connection with the pump, the mixture should be frequently stirred while being applied.

The directions given above were followed during the past year with good results. While the check plat, No. 30, which was not sprayed does not show much falling off in yield over plat. No. 29, yet we believe that as a matter of policy, spraying should be practiced. When the blight does appear it comes so suddenly and usually with such virulence that nothing can then be done to prevent its ravages. As a preventive measure spraying with Bordeaux mixture should become the general practice instead of the exception.

The July drought.—During July there prevailed a most severe drought. The amount of moisture on some of the plats was reduced to four per cent as determined by samples taken one foot deep. This condition threatened to seriously injure the crop and no doubt did effect it to some extent.

The soil having been thoroughly prepared and the potatoes covered deeply, and the surface kept loose, the plants were able to survive and produce a very satisfactory crop. We learn that some farmers who followed the directions given in the previous bulletins met with failure of the potato crop owing to the July drought. The potatoes were planted at such a time that the new tubers were just setting at the time of the drought, with the result that they failed to set fully. Had they been planted earlier or later the probability is that a better crop would have resulted.

The frequency of droughts enforces the importance of having a soil well supplied with humus, early plowing, deep planting of the potatoes, especially on porous, leachy soils, and frequent tillage.

LESSONS DRAWN FROM THE EXPERIMENTAL POTATO PLATS IN 1898.

A study of the table giving yield of plats from 21 to 29 inclusive will show that there is not a wide range in yield from those plats but that all are well above the average. The extra tillage does not seem to have produced the marked results that were shown in the previous experiments and this was probably due to excessive droughts preceded and followed by excessive rains. When a study is made of the table giving yields, a study should also be made of the table showing what crops have been produced on each plat during the past five years. All of these crops have been well above the average and the annual drain upon the soil has been greater than upon ordinary soils. To explain the uniformly high yield we must then make a study of the treatment which all plats have received. It is probable that frequent and deep plowing has done much to bring and keep the land productive. So far as the plowing is concerned all plats have received the same treatment. The land has been turned from two to three times each year, and the pulverizing which has resulted therefrom has liberated sufficient plant food to mature large crops. In addition to the plowing the land has been frequently harrowed and cultivated and the intensive culture which has been given has liberated all the plant food that could be used by the growing crops with the amount of moisture that was present.

Plats 30 and 32 were not sprayed. Paris green was applied with plaster to kill the Colorado potato beetles. The potatoes grown on Plat 32 were the same variety as those grown upon Plat 21 which was kept well sprayed. It is not probable that the spraying alone was responsible for the wide difference in yield as the land becomes more gravelly in texture and hence more leachy as it approaches Plat 32. The variety, Mill's Endurance, is said to be blight proof and it does seem to possess to a remarkable degree qualities which enable it to resist blight. Plat 32, though it was not sprayed, remained in fairly good condition until killed by frost. On Plat 21, the same variety which was sprayed with Bordeaux mixture, the foliage remained remarkably healthy and vigorous, and even though the variety seems to be exceedingly hardy, yet the effect of the spraying was very marked.

On Plat 31 the variety, Rose of Sharon, seemed utterly unable to resist the blight. It was sprayed seven times with Bordeaux mixture and finally succumbed to blight in the early part of the season. The varieties which have with us proven most satisfactory are Carman No. 3, Rural New Yorker No. 2, and Mill's Endurance.

Field potatoes.—An area of 1.01 acres, the larger part of which had been devoted for several years to the raising of mangold wurzels, was planted to potatoes May 28. The land was fitted similarly to the manner described on the plats. Part of this land had been fertilized for several years with annual applications of barn manures, and had been brought into good condition.

Preparation of the seed.—About three weeks before the potatoes were planted the seed was cut. It was the purpose at the time of cutting the seed to plant the potatoes within a few days, but almost continuous rains delayed the work until the end of May. The potatoes which had been so long cut had been very much weakened in vitality, having heated and moulded somewhat. They were planted, however, and the stand secured was very poor, a considerahle portion of the field having to be replanted.

The furrows for the potatoes were opened with a double mold-board plow, the rows forty inches apart and the potatoes were dropped one piece in a place at distances of 14 to 18 inches apart. The double mold-board plow was then used in covering the potatoes and the soil was left ridged up above the rows. As a portion of the field was a clay loam soil and rather wet at the time of planting, the harrow was used within one week and the ridges were leveled down and clods were pulverized before they became too hard and dry to crush easily. The soil was warm and moist and the potatoes came up quickly. About the time they were breaking through the surface the weeder was used with good results. It broke the crust and destroyed weeds that could not be reached with a cultivator. Bordeaux mixture with Paris green was used five times and five cultivations were given. The yield from the field containing 1.01 acres was 216 bushels, or a yield of 214 bushels per acre.

Lessons drawn from the acre of potatoes.—Seed should not be cut for any considerable period before planting. If it becomes necessary to delay planting for some considerable time after potatoes are cut, the cut pieces should be dusted with plaster and spread out in a moderately moist, cool place. At least they should not be allowed to heat, neither must they be allowed to become dry.

If planting is done very early in the spring the ridges may be permitted to remain for ten days to two weeks before harrowing down. If planting is done somewhat late the ridges should be harrowed within one week after planting. In the case of the early planting there is usually enough moisture present so that the ridging may temporarily prove a benefit by enabling the soil to become warm. In the case of late planting all the moisture should be conserved, and this is best done by leveling the ridges. Where the soil is naturally too wet the ridges may be beneficial in that they hasten evaporation and the consequent drying of the soil.

Several causes contributed to the low yield on the acre field, chief among which were seed which had become weakened in vitality thus necessitating replanting, late planting, excessive drought in July, followed by excessive rains. While the land had been receiving fairly liberal applications of manure and was in a good state of fertility, yet the causes above mentioned conspired to produce but little more than half the crop which should have been produced under favorable conditions.

I. P. ROBERTS,
L. A. CLINTON.

Bulletin 157. December, 1898.

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

ENTOMOLOGICAL DIVISION.

THE GRAPE-VINE FLEA-BEETLE.

BY M. V. SLINGERLAND.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1898.

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The regular bulletins of the Station are sent free to all who request them.

CORNELL UNIVERSITY, ITHACA, N. Y., Dec. 8th, 1898.

THE HONORABLE COMMISSIONER OF AGRICULTURE,
ALBANY, N. Y.

Sir:—This bulletin embraces the results of long investigation and observation of the grape-vine flea-beetle and is submitted for publication under Chapter 67 of the Laws of 1898.

The difficulties of combating this pest of the vineyard have heretofore appeared to be insurmountable. The life-history and habits of the beetle have been discovered, and the results of numerous experiments indicate that it is not more difficult to destroy than many other pests.

The bulletin certainly emphasizes the need of being alert and observing. The mistake in the past seems to have been that the enemy was allowed to do its work before an effort was made to destroy it.

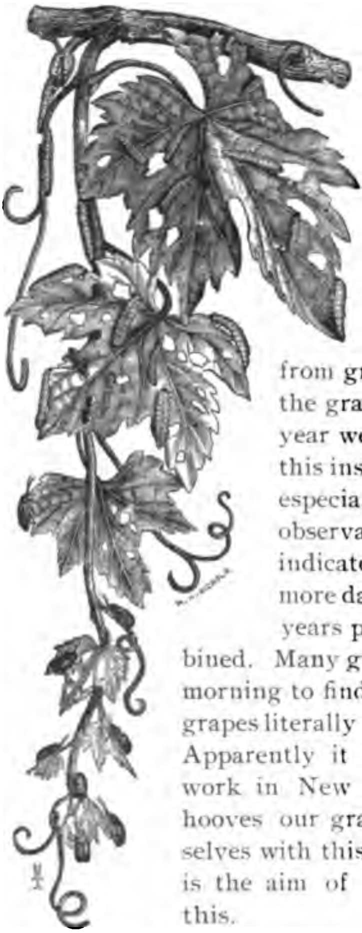
This bulletin will commend itself, we believe, to the grape-growers of the country not only because of its completeness and of the care which has been exercised in the work necessary to secure the facts embodied in the publication, but because of its practical value to the grape industry.

I. P. ROBERTS,
Director.

THE GRAPE-VINE FLEA-BEETLE.

Haltica chalybea Illiger.

Order COLEOPTERA ; family CHRYSOMELIDÆ.



11. *Grape-vine Flea-beetles and their grubs at work, natural size.*

In general, insect enemies are not a serious drawback to grape-growing in New York : the vineyardist usually suffers much less from their ravages than the orchardist. While most of the common injurious insect pests of the grape-vine are to be found in New York vineyards, by far the larger proportion of complaints of insect ravages which reach us from grape-growers refer to the work of the grape-vine flea-beetle. Almost every year we receive several inquiries about this insect, and the complaints have been especially numerous during 1898. Our observations and correspondence would indicate that this flea-beetle has done more damage in our vineyards for several years past than all other insect foes combined. Many grape-growers have awakened some morning to find all of their prospective crop of grapes literally "nipped in the bud" by this pest. Apparently it is the worst insect pest now at work in New York vineyards. Hence, it behooves our grape-growers to familiarize themselves with this flea-beetle and its life-story. It is the aim of this bulletin to help you to do this.

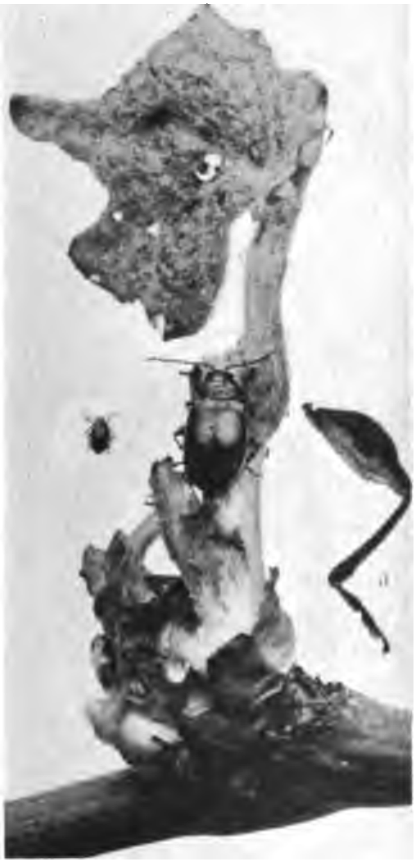
THE HISTORY AND DISTRIBUTION OF THE INSECT.

Nearly a century ago specimens of this flea-beetle from Georgia and Pennsylvania found their way into European collections, and in 1807 it was described and given its scientific name by Illiger, a German. The year previously it had been listed in America in a published catalogue of the insects of Pennsylvania (see the first reference in the Bibliography). In 1824 the insect was again described under a different name by our famous American coleopterist, Le Conte. He states that it occurred from New York to Georgia; thus the insect has been a native of our state for at least 75 years.

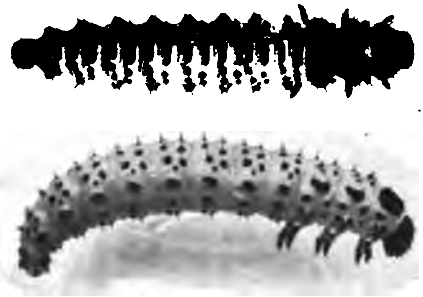
Apparently nothing was known of the habits of this flea-beetle until about a quarter of a century after it was first found and described. In 1834, David Thomas recorded that it appeared on grape-vines in considerable numbers in Cayuga county, N. Y., near Philadelphia, Pa., and in New Haven, Conn., and vicinity, in the spring of 1831; in 1830, Thomas saw the grubs at work on grape leaves but did not recognize them as belonging to this insect until he raised the adult insect in 1832.

The literature during the next thirty years contains several records of injuries by this flea-beetle in different parts of the country. In 1860 it was very injurious in Delaware, and also during the next three years in various parts of New York; as early as 1863 it was reported as injurious as far west as Wisconsin. By 1870 its life-history was fairly well understood by entomologists, and most subsequent accounts of it, except Comstock's in 1880, are compilations.

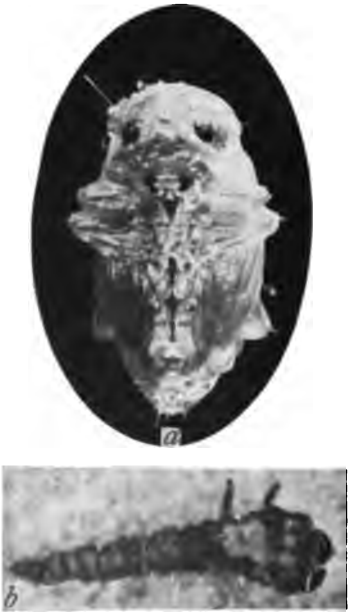
During the past thirty years this flea-beetle has seriously damaged vineyards in widely separate portions of the country every year, and it has been discussed by nearly all the prominent writers upon injurious insects. It is a native of North America and occurs throughout the eastern half of the United States from New England southward to southern Florida, and westward through Canada and southern Michigan to southern Minnesota, thence southward to eastern and southern Texas; its western-



12.—*The Grape-vine Flea-Beetle, natural size and enlarged.* a, *hind leg of the beetle much enlarged.*



13.—*Dorsal and lateral views of a grub of the Grape-vine Flea-beetle, enlarged.*



14.—*a, pupa of the Grape-vine Flea-beetle. b, cast-skin of one of the grubs.*

most recorded limits are eastern Kansas and eastern Nebraska*. The insect doubtless occurs in injurious numbers in most of the grape-growing regions within the boundaries of this vast territory. Judging from the number of reports of its ravages which have reached us during the past few years from the great grape-growing sections of central and western New York, this flea-beetle must be present in alarming numbers in these regions and is apparently on the increase.

It doubtless occurs in all parts of New York where grapes grow, but its injuries are usually confined to a limited locality each year. We have no report of its having been destructive over an extensive area, even in the great grape-growing districts of the state; but often reports reach us where a few vines in a village yard or a certain block of vines in a large vineyard are stripped of their buds by the insect, while a neighbor's vines a few rods away suffer very little, if any, damage. Thus, although the insect is generally distributed, its occurrence in injurious numbers is usually over limited areas in New York state.

DESCRIPTION OF THE INSECT.

This insect enemy of the grape-vine is one of that group of leaf-feeding beetles known as the flea-beetles. The thighs of the hind legs of these beetles are much thickened (Fig. 12 *a*), thus fitting them for jumping quickly like fleas. The grape-vine flea-beetle is a small, dark, glossy, greenish-blue or steel-blue beetle measuring only from 4 to 5 mm. (a little less than one-fifth of an inch) in length; its color varies occasionally to purplish, brownish or greenish. The beetle is shown natural size and enlarged in figure 12. As it is the only small, blue beetle that occurs in injurious numbers upon the grape vine, it should be a very easy matter for the vineyardist to discover the culprit. The beetles may be found at work on the vines in May and June, and again in July.

While most of the damage is done by the adult insect or beetle,

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*Mr. E. A. Schwarz writes us that "The grape-vine *Haltica* of the Pacific slope and Arizona cannot possibly be *Haltica chalybea*, because this species does not occur in the region just mentioned. It is replaced there by *Haltica carinata*."

the leaves of the vine also serve as food for the earlier or grub-stage of the insect. Sometimes considerable damage is done by these grubs or larvæ. It is very important that grape growers should also be able to recognize the grubs, for most of the damage which the insect might do the succeeding season could be averted by killing them. The little dark-brown grubs, shown natural size at work in figure 11, begin to appear on the leaves during the latter part of May and are at work during the most of June in New York. When full grown the grubs measure from 7 to 9 mm. (.275 to .354 inch) in length. They have the six true legs typical of insects, and also one fleshy, yellowish false or pro-leg on the anal segment. They are of a dark yellowish-brown (nearly Ridgeway's raw umber) color, lighter and more yellowish on the venter; the younger grubs are considerably darker in color. The head and thoracic legs are shining black, while the thoracic and anal shields are not quite so densely black in color. The body is marked with regular rows of blackish spots, each bearing a short hair; the size and arrangement of these spots is well shown in figure 13. Fortunately these little brown grubs usually work on the upper side of the leaf so that, although they are only a little more than a quarter of an inch in length, they are easily found by children's sharp eyes.

In the other two stages of its existence—the egg and the pupa—this flea-beetle does no damage. These stages are illustrated and discussed in telling the life-story of the insect.

ITS NAME.

When this flea-beetle was first described nearly a century ago it was given the very apt scientific name of *chalybea;* this word means "steel-blue," the usual color of the beetle. Dr. Harris, in discussing the insect in 1841, popularized this name into "the steel-blue flea-beetle,"and also suggested that it might be called "the grape-vine flea-beetle" on account of its habits. Both of these popular names are now in common use, and the former has been shortened by many grape-growers to "the steely-bug" or "steely-beetle." All of these names are very apt and suggestive and we are not sure that the more appropriate one has been chosen for the title of this bulletin.

ITS FOOD-PLANTS.

The natural food-plant of the grape-vine flea-beetle in most parts of the country is doubtless the wild grape, upon which it is often found feeding in both the grub and beetle stages. Other wild plants must serve as natural food for it in some parts of the country; Mr. E. A. Schwarz has found the beetles "abundant on various trees in the semi-tropical hammock of Florida, where the species of *Vitis* do not occur."

Food of the beetles.—The beetles have been found feeding on various plants. In 1856, Dr. Fitch recorded that "a young plum tree in my yard had its leaves nearly all destroyed by this insect, every summer, for many years in succession, and other trees near this were more or less injured;" Britton reports a similar case in Connecticut in 1897. They were reported as feeding on elm by Glover in 1863; in 1888, McMillan stated that in Nebraska the beetles had done much injury to seedling apple, pear, quince and plum trees by eating out the buds, often thus destroying many grafts; in 1892, Schwarz stated that he had found the beetles in great numbers on *Carpinus* (Blue or Water Beech) in Maryland; and they have been found working on the fruit buds of the Dutchess of Oldenburg apple in Minnesota.

Is alder its food-plant?—Most writers in discussing this flea-beetle have quoted the black alder (*Alnus serrulata*) as one of its food-plants. We have traced this statement through the literature to a paper by Dr. Harris published in 1854; in discussing the grape-vine flea-beetle, he states that in a recent excursion to New Hampshire he found large numbers of the beetles and grubs feeding on black alders. However, in Harris' Entomological Correspondence we find practically the same account under the name of *Haltica alni* Harr. MSS.; the dates in the two accounts are the same. Doubtless further study of specimens collected on the alder in 1854 convinced Dr. Harris that they were specifically distinct from the grapevine flea-beetle, and he gave them the above manuscript name; this insect is now well known as the alder flea-beetle (*Haltica bimarginata* Say). Hence, it is very doubtful if the black alder should be included among the plants upon which the grape-vine flea-beetle, especially the grubs, feed.

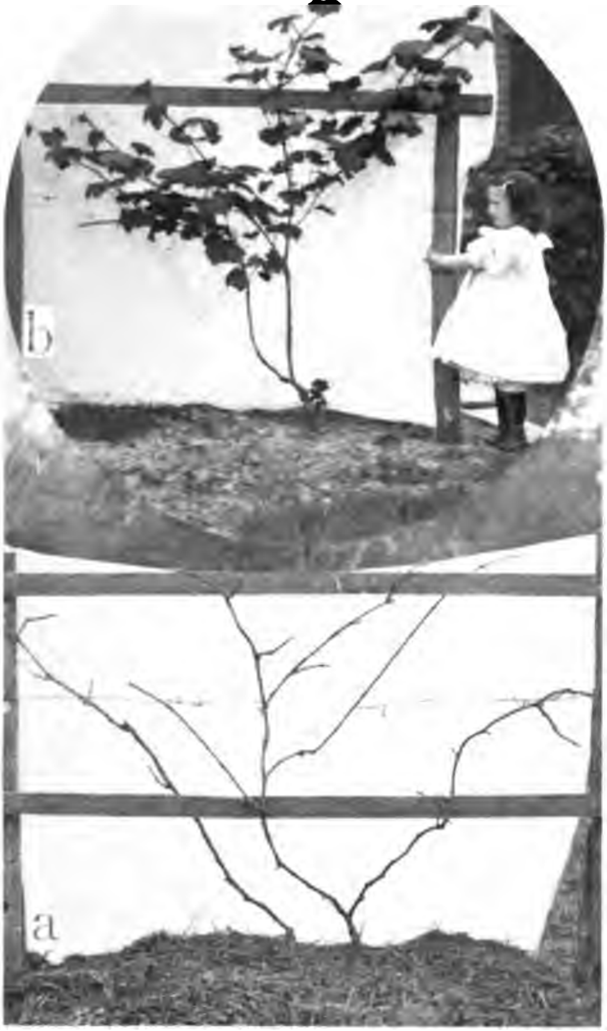
Food of the grubs.—While the beetles are quite general feeders, the grubs have been found on but few plants. Most records mention them as feeding only on the leaves of the grape. In

1890, Neal stated that in Florida, "these beetles, both as larvæ and as perfect insects, are injurious, eating the leaves of the plum, grape and peach." In some sections the Virginia Creeper (*Ampelopsis quinquefolia*) seems to be a favorite food-plant for the grubs and beetles. Bethune recently reports that in Canada the insect has been very destructive of late years to the foliage of this vine, the vines were often completely stripped of their leaves before the end of August. Strange to say, a grape-vine against a fence only a few yards from some badly infested creepers was not attacked at all.

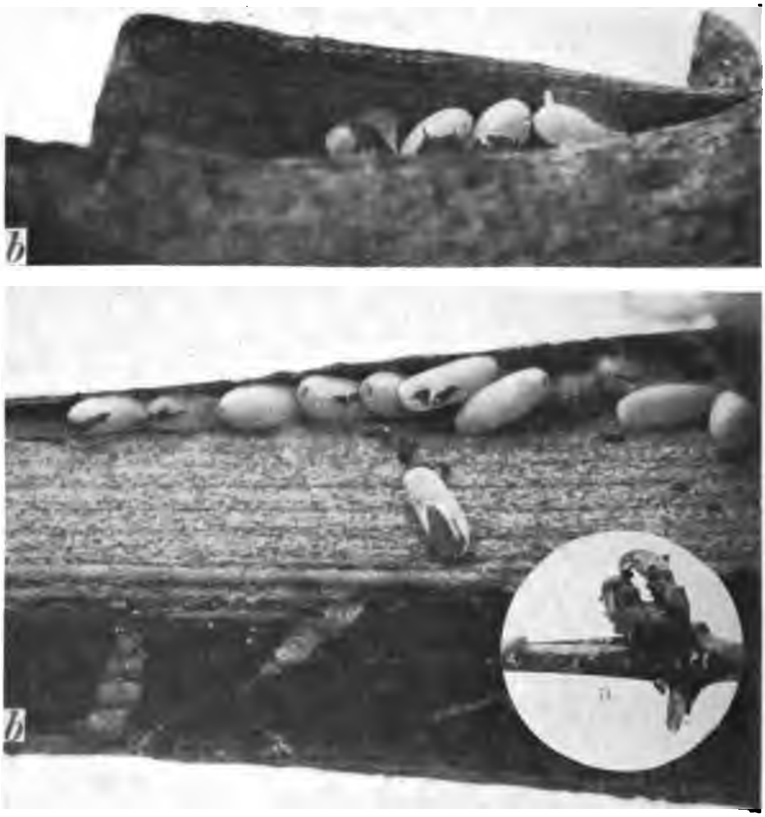
Preference for varieties of grapes.—This last fact suggests the question sometimes asked us: Does the flea-beetle attack some varieties of grapes in preference to others? In 1884 one of Mr. Fletcher's correspondents in Canada found that they attacked the Concord grape more than any other. Mr. A. T. Beardslee, Himrod, N. Y., wrote us in June, 1898: "I saw a vineyard of Clinton grapes which was totally devastated by the steely-beetle, while a vineyard of Concords right over the fence remained untouched. The pests commenced eating on the side of the vineyard next to the Concords, and therefore must have passed over the Concords to get at the Clintons. Nothing was left except the hard wood of the vines." Thus the evidence is conflicting and indicates that certain varieties may suffer more in some localities from this flea-beetle than in others, and there is no way of foretelling which variety it may damage the most in any locality.

HOW THE INSECT WORKS, AND ITS DESTRUCTIVE CAPABILITIES.

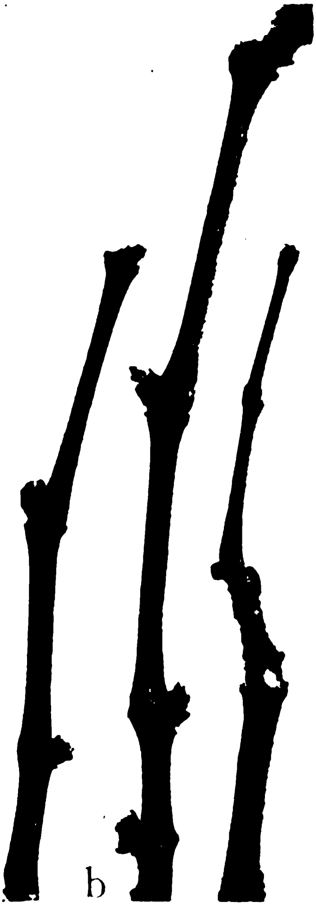
Fortunately the work of this flea-beetle in a vineyard is easily seen and recognized when one knows what to look for; but, unfortunately it has usually done most of the damage before one suspects that anything is wrong with the vines. Usually it is not until the grape-grower awakens some morning early in the spring to discover that some of his vines have not started into growth as others have. Oftentimes the few vines in some village yard will leaf out all right in the spring, while a neighbor's vines, perhaps only a few rods away, will have the appearance of



16.—*Two grape-vines as they appeared on June 6, 1898, in neighboring village gardens. On vine* (a) *not a bud had escaped the jaws of the "steely-beetle," while vine* (b) *had suffered but little.*



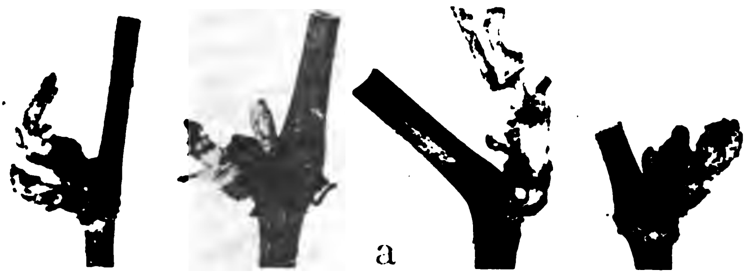
17.—*Eggs of the Grape-vine Flea-beetle ; natural size at* a, *and enlarged at* b, b.



the vine shows at *a* in figure 16. Figure 16 vividly portrays such a case; vines *a* and *b* were in neighbors yards less than five rods apart, and both pictures were taken on the same day, June 6th, 1898.

A careful examination of the buds on vines which thus fail to start normally in the spring will soon show if it is the work of the flea-beetle. Oftentimes many of the buds will be found to have been nearly all eaten up and are dead, like those shown at *b* in figure 15. Many of the buds, not so badly eaten may have just begun a weak, discouraged and deformed growth, like the buds shown at *a* in figure 15. A little further search on the vines at this time will usually reveal the culprit—this steel-blue grape-vine flea-beetle. Often some of the beetles can be caught at their destructive work, perhaps just in the midst of getting their breakfast off one of the buds.

By far the greatest amount of damage done by this grape pest



15.—a, *Grape buds badly damaged by Grape-vine Flee-beetles;* b, *buds killed by the beetles. Natural size.*

is in its attack on the buds in early spring. It has been recorded that vines are often killed to the ground by the attack of the beetles at this time; we have never seen so severe an attack in New York. We have often seen a grape-vine looking almost as bare as *a* in figure 16 in June, recuperate to such an extent that before the summer is over, we would never suspect that it had been injured by this insect, except that such vines lack the element of profit—the fruit.

Thus these flea-beetles, by eating the buds in the spring, attack a very vital part of the vine, so far as the grape-growers pocket-book is concerned. For it is on the season's growth from these buds that all the fruit is borne, and, therefore, every time that the beetle eats a bud, it destroys the crop of fruit which that part of the vine might have produced.

This grape-vine flea-beetle is thus capable of nipping in the bud, the entire crop of fruit, but fortunately it seems to have thus far accumulated in sufficient numbers to do notable injury only over small or isolated areas.

While most of the destruction wrought by this pest is done by the beetle in eating into the buds in the spring, the grubs, or progeny of these beetles, feed upon the leaves later and often do some damage. And again, the beetles which develop in July and August from these grubs, also feed on the grape leaves usually, however, doing no noticeable damage. The work of both the grubs and this later crop of beetles is easily recognized. In figure 19, page 205, is shown a branch on which most of the leaves have been riddled by the grubs; in figure 18 is shown one of the injured leaves natural size. The work of the beetle on the leaves is similar to that of the grubs. This riddling and skeletonizing of the foliage is done by the grubs in June and continued later by the beetles. As many such riddled leaves on the vine presages a destructive crop of the beetles to feed on the buds the next spring, grape-growers finding such leaves should be on the lookout for the pest as soon as growth begins in the spring.

THE STORY OF ITS LIFE.

Appearance and habits in the spring.—The little steel-blue beetles come from their winter quarters in the north in April, or as soon as the grape buds begin to swell and burst ; sometimes April weather is so cold and unpropitious that the beetles do not appear until in May. They jump or fly to the nearest vine and soon begin to satisfy their appetites sharpened by a long winter's fast. The tender bursting grape bud seems to be the only item on its menu, and it proceeds to gorge itself with bites from the prospective crop of fruit then locked up in the buds. The beetles seem to be the most active during the warmer, sunshiny portions of the day, when they may be seen jumping and flying about the vines. When touched or jarred, they at once drop quickly to the ground where they " play possum " for a short time. Their shining blue color renders it easy to discover and watch them at their destructive work. They begin gnawing an unsightly hole into either the side or top of the bursting bud, and oftentimes boring into the bud so far that they are almost hidden from view. How many grape buds one of the beetles may thus damage, we cannot say ; doubtless several buds are tasted or sampled by each beetle.

It usually takes the beetle a few days to satisfy their vigorous spring appetites, then they begin to turn their attention to the propagation of their kind. Early in May one can often find the beetles in copulation on the vines, often on a bud. Egg laying soon begins.

The egg stage.—Oviposition must have begun with this insect at Ithaca, N. Y., during the first half of May in 1898. How many eggs each female may lay or over how long a period oviposition extends, we have not yet determined. We found the beetles in copulation and freshly laid eggs as late as June 15th, 1898 ; this would indicate that either some of the beetles emerge from hibernation much later than others, or that it takes a female several weeks to lay her stock of eggs.*

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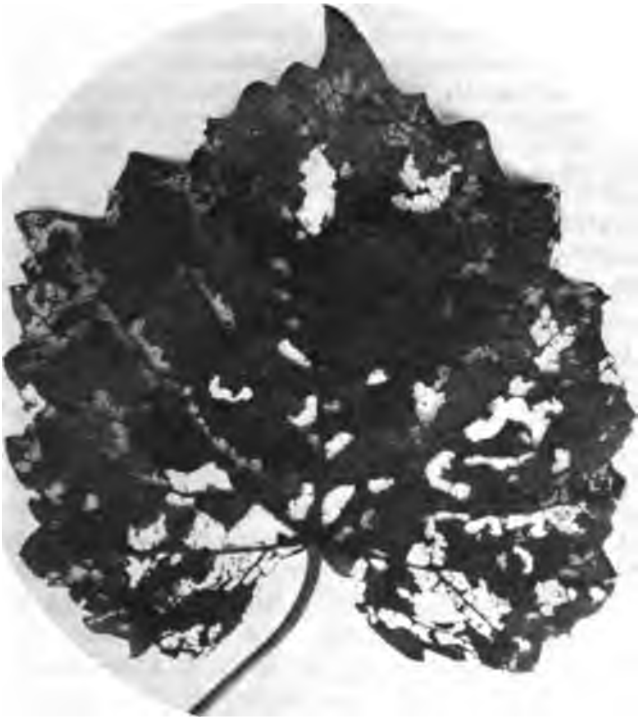
*On July 15th, 1898, Mr. V. H. Lowe, entomologist at the New York State Experiment Station, wrote us that " Yesterday while looking through some vineyards near Bluff Point, N. Y., I found a few eggs on the underside of a leaf. The adult female was there and had evidently just deposited them." We are unable to satisfactorily explain this instance of late oviposition. It may be that this female was so belated in emerging from hibernation as to have not yet finished laying her quota of eggs. The possibility of there being a second brood of the grubs in New York will be discussed later under the heading, the number of broods.

Most writers who mention the eggs, state that they are laid in small clusters on the leaves. Consequently, as soon as we saw the beetles in copulation in May, a careful search was made for eggs on what few leaves had then expanded. We found none, and failed to find any on the leaves in 1898 at Ithaca, N. Y., the few found June 15th, were among the hairs on the stem of a leaf. Our observations indicate that most of the eggs are laid before but few, if any, leaves have expanded. We finally found the eggs in the place shown in figure 17. Most of them were tucked into a crack of the outer bark at the base of the buds, many were scattered in any crevice which afforded room on the base of the bud, and a few were found in the cavity which the beetles had eaten in a bud. These observations agree with those recorded by Perkins in 1878. But Comstock reports in 1880 that "the eggs are laid in irregular clumps of four or five, more or less, both upon the upper and under sides of the leaf. Rarely a few eggs are to be found upon the unopened buds, and the beetles, if caught early in the season and kept in confinement, will oviposit profusely upon any substance whatsoever."

The long, oval shape of the eggs is well shown in figure 17. They are of a darkish straw color (very near Ridgeway's saffron and buff yellow) and average .65 mm. (.03 inch) in length. Their surface presents a dull, roughened appearance, but we were soon surprised to find that this rough exterior layer often cracked open and partially peeled off the egg; this is shown on several of the eggs in figure 17. We found that by a little careful manipulation with a needle, this rough layer could be entirely scraped off from an egg. Whether this layer is a part of the shell of the egg or simply a protective coating secreted over the egg, we did not determine; it was so regular in thickness and presents such a shell like appearance on the outside, that it would seem to be a part of the egg-shell. Its peeling off is a curious phenomenon which we have not before encountered in our study of insects. Beneath this rough coating the egg is smooth and of a shiny, light lemon-yellow color.

How long the egg stage lasts, we did not determine, and the only statement we have found regarding it is by Perkins, who says that "they hatch in about three weeks." Doubtless climatic changes influence the duration of the egg-stage somewhat. At Ithaca, N. Y., the eggs had just begun to hatch on May 27th, 1898; the first leaves had just expanded.

Habits and growth of the grubs.—In Georgia, the young grubs have been found at work as early as March 15th, but in the North, it is usually during the latter part of May that the grubs begin work. The newly hatched grubs are scarcely a sixteenth of an inch long and of a very dark brown color, almost as dark as the blackish spots on the body. We saw some of them get their first meal on the buds what were struggling to make a little growth with what life was left after being ravaged by the beetles. Usually, however, the little grubs make their way to the young leaves, where they begin to eat little irregular holes through the skin and into the soft inner tissues. Fortunately for the grape-grower, these grubs work almost entirely upon the upper side of



18.—*A grape leaf riddled by the grubs of the Grape-vine Flea-Beetle. Natural size.*

the leaf where they can be easily gotten at with a spray. Several of the grubs usually work on the same leaf, continuing to eat small irregular holes, through or nearly through the leaf until it is pretty well riddled like the one shown in figure 18, when they seek new pastures. Where the grubs are numerous, all of the leaves on a branch may be riddled, as in figure 19, page 205.

As the grubs increase in size they have to shed their skin from time to time, at least two or three times. In shedding their skin or moulting, the old skin splits down the back, about a third of their length, and the grub with its new suit quietly crawls out, leaving its old suit stretched out on the leaf resembling somewhat one of the grubs which might have gotten too warm and had simply unbuttoned its coat down the back a little way to cool off. One of these cast-off suits is shown magnified, at *b* in figure 14.

The grubs continue to feed upon the upper surface of the grape leaves for three or four weeks before they attain their full growth. The full grown grub is represented in figure 13. They are then scarcely a third of an inch long and their general color is considerably lighter than when young, so that the dark markings are more easily distinguished. Owing to their small size, the grubs of this grape pest are not often noticed by the grape-growers ; in fact we fear that but few who suffer from this insect are familiar with it in the grub state. However, the work of the grubs is easily seen, and grape-growers should learn to know them, for one of the most effective methods of controlling the insect depends upon this knowledge. In New York the grubs are to be found at work during the first three weeks in June.

The pupa stage.—When the grubs have fed sufficiently they drop from the grape leaves, and after working their way for from one-half an inch to two inches in the ground, they twist and roll themselves about until a small smooth cavity is formed around them. In this cavity they change in a few days to the inert stage in their existence—the pupa. In New York many of the grubs were full grown by June 15th, 1898, and a few days later most of them had left the vines and disappeared in the ground. By June 27th most of them were in the pupa state in their little earthen cells.

One of these pupæ is shown, much enlarged, at *a* in figure 14, facing page 191. They are of a saffron-yellow color, with reddish-brown eyes. Each segment bears a row of short blackish hairs across the dorsum, and a pair of comparatively large, curved, blackish spurs project caudad from the dorsum of the anal segment.

In our cages in the insectary, the pupal stage of this flea-beetle lasted but little more than a week; for on July 7th, the pupal skin had been cast off and the mature or adult insect—the steel-blue beetles—had begun to emerge from the soil. The indications were that the beetles remained in the earthen cells or pupal homes for a day or so before emerging. They continued to emerge in our cages for a week or more.

Habits of the beetles in the summer.—Fresh grape leaves were placed in our cages where the flea-beetles began to emerge from the ground on July 7th. They at once began feeding upon the leaves, eating small irregular holes, usually from the upper surface, nearly through, often leaving part of the fuzzy, lower skin of the leaf. Leaves upon which they fed looked very much like those eaten by the grubs in June; thus figures 18 and 19 will serve to illustrate both the work of the grubs and of the summer brood of the beetles. The beetles in our cages fed almost continuously for many days; their little string-like pellets of excrement were thickly scattered over their feeding grounds. Some of the beetles thus continued to feed on the fresh grape leaves placed in the cages for nearly two months. The cages were left in a warm greenhouse, and yet many of the beetles ceased feeding and hid themselves in the refuse of dead leaves at the bottom of the cage.

Thus there is no question but what the beetles which emerge in July feed during the rest of the summer, and they evidently thrive upon grape leaves. Comstock records that he had heard reports of considerable damage being done to the grape-vines by the beetles in the summer. But is the grape-vine their favorite food-plant during the summer? During July and August, when the beetles were feeding ravenously on the grape leaves in our cages we made several attempts to find them or evidences of their work in vines which had been quite badly damaged by the beetles on the spring and by the grubs in June. Our efforts were unsuccessful, yet we feel sure that these vines will be badly damaged by the beetles in the following spring. Our observations would indicate that the summer brood of these beetles must sometimes feed upon several other plants beside the grape. Dr. Fitch records that they fed upon one of his plum trees every summer for many years.

Number of broods each year.—In 1865, Kirkpatrick thought there were several broods of this flea-beetle each year. Most later writers say one brood, while some suspect two broods in the south. There is, as yet, no definite evidence to show that two broods of the beetles and their grubs are produced in a year in any portion of the country, although such a definite statement has crept into one of our best popular books upon injurious insects. As the grubs get to work as early as March in Georgia and Florida, it would seem very probable that another brood of grubs would be developed there before autumn. Bruner has noted but a single brood in Nebraska. In June, 1898, we collected many of the first grubs to be found that had attained nearly their full growth and placed them in cages. The first beetles to develop from these appeared July 7th. We fed the beetles for about two months, and during that time failed to see any in copulation or any indications of egg-laying. They then ceased feeding and prepared for hibernation. This indicates but one brood, normally, in New York.

As recorded on page 195, we found freshly laid eggs on June 15th, 1898, and Mr. Lowe found some as late as July 14th. It is possible this last case means that there may sometimes be a partial second brood of the grubs in New York, but we prefer to believe it a case where the beetle emerged from hibernation much later than usual in the spring, and possibly its egg-laying period was unusually long.

Most writers speak of the beetles which appear in July as the "second brood." There is but one brood of the beetles in a year in northern latitudes at least. It is true, however, that members of two different broods of beetles appear on the vines during the same calendar year. But the beetles which appear and feed on the leaves in July and August are the same ones that one sees eating the buds the next May.

How the insect passes the winter.—In 1859, Dr. Fitch found the beetles torpid in winter beneath loose scales of bark on the vines and under particles of dirt at the base of the vine. This fact, that the insect passes the winter in the beetle state, has been confirmed by all later observers. The beetles hibernate in almost any crevice which will afford them shelter; the rough bark of the supporting posts, under the outer bark at the base of the vines themselves, in the joints of neighboring fences, under sticks, stones, or logs upon the ground, all these are favorite places for their hibernation, One observer (Fisher, 1879) reports that they appear to prefer to hibernate in adjoining grass-grounds or in other substances about, rather than in the vineyard; in vineyards kept clear of all rubbish and other possible hibernating shelter, this is doubtless true. Our breeding experiments detailed above, indicate that the beetles which are developed in July in New York feed during the summer, and finally go into hibernation early in autumn, possibly sometimes as early as the latter part of August. It is these hibernating beetles which emerge from their hiding places in April and May, or earlier in the South, and, with appetites sharpened by their long winter's fast, devour the bursting grape-buds.

ITS NATURAL ENEMIES.

Like most other insect foes of the fruit-grower, this grape-vine flea-beetle has its natural enemies which render more or less aid in reducing its numbers. It is probable that the beetles are sometimes attacked by a fungous disease, for Comstock records receiving specimens from Georgia found under the bark of vines that were fastened to the bark and surrounded by a mass of white fungous spores.* We have not heard of any fungous-killed beetles being found in New York.

In 1889, the late Mr. George C. Snow, Penn Yan, N. Y., detected a nymph of one of the common "stink-bugs" sucking the juices out of the grubs of this flea-beetle. The nymph was sent to Dr. Lintner, who referred it to an expert, Dr. Uhler, by whom it was determined as probably the "stink-bug" known as *Podisus modestus* Dallas. In 1856, Dr. Fitch recorded this bug as puncturing grape leaves; it is more likely, however, that the bug was on the vines for the more useful purpose of sucking the juices from some of the grape-growers insect foes.

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* In the Year Book of the U. S. Dept. of Agriculture for 1895, is figured, page 395, without comment, an instance of the beetle having been killed by a fungus.

On May 30, 1898, we saw one of our most common lady-bird beetles (*Megilla maculata*) eating a young grub of the grape-vine flea-beetle. Thus this pest has its enemies in New York, but, thus far, they have apparently done but little to hold it in check in most localities.

HOW THE INSECT MAY BE CONTROLLED.

This grape-vine flea-beetle is not a difficult insect to combat *when one understands its habits and life-history.* This last clause is italicized because we believe that to a lack of such knowledge is largely due the frequent reports one hears of grape-growers being unable to check the insect in their vineyards. The insect is vulnerable and readily gotten at in two of its stages—as a beetle and as a grub.

Much good can often be accomplished by going through the vineyard, either in the fall, winter, or early spring, and removing and burning all loose bark and splinters from all the vines, and all rubbish from the vicinity of the vines, thus destroying many of the beetles in their hibernating quarters. Comstock records an instance where a Georgia grape-grower reduced the crop of beetles from several bushels to only about a hundred individuals by thus thoroughly going through his vineyard twice in the winter.

Do not allow the beetle to get the start of you in the spring. Be on the lookout for them as soon as the grape buds begin to swell, or during the first warm spell in early spring. Remember that in one day at this time a single beetle is capable of doing more damage than all of its progeny may do during the rest of the season. Your crop of fruit for the season is locked up in those few buds which the pruning-knife leaves on each vine, and it does not take long for the hungry beetles to "nip the crop in the bud." Often grape-growers do not realize that the insect is present in their vineyards in alarming numbers until most of the damage is done.

There are two methods of combating the beetles in early spring when they emerge from hibernation and attack the bursting buds. They may be collected by hand, or the spraying machine may be brought into use. Both methods are practicable and have proven successful when properly applied.

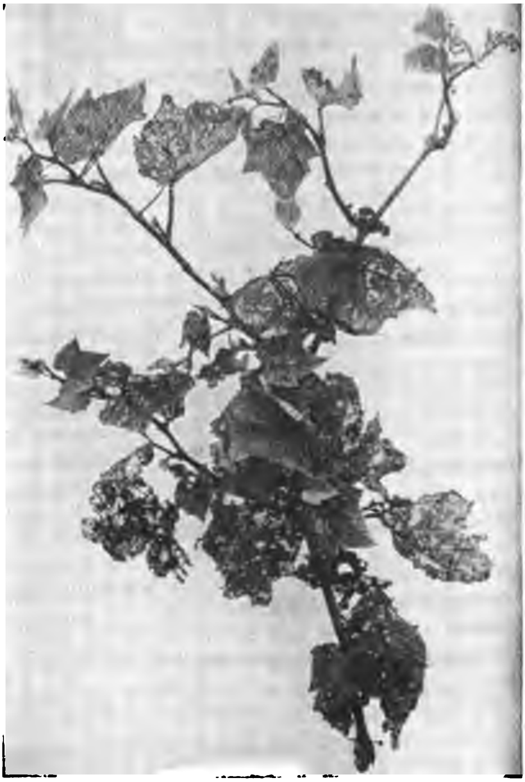
On a few vines in a village yard or in the farmer's garden, it should be an easy matter to control the pest by examining the vines carefully each morning in May, or oftener if necessary, and crushing in the fingers or otherwise all the beetles to be found. Or the beetles can be readily jarred into a pan of kerosene; this method is often practiced, even in large vineyards. The following modification of this method has been successfully employed: A strip of cotton cloth, 3 by 6 feet, kept open by cross-sticks at the ends, is thoroughly saturated with kerosene and held under the vine, while the supporting-post, or the vine itself, is struck a sharp blow with a club. The beetles readily fall by the jar, and contact with the kerosene sooner or later destroys them. Doubtless it may be found advisable in some cases to use two of these sheets in order that the vine may be more completely surrounded. With this simple apparatus three boys can go over a large vineyard almost as fast as they can walk; and if this be done every day, say for a week, in an infested field, the beetles will be quite thoroughly destroyed. After striking the saturated sheet the beetles show no disposition either to fly or jump. To prevent the possibility of any which might strike the sheet near the edge from crawling off and escaping, simply stitch a rim of cotton batting to the edge of the sheet and saturate it also with kerosene.

A few years ago the beetles destroyed nearly all the buds on some vines near the insectary before we were aware what was the cause of the vines not "starting" in the spring as did others not far away. It was then so late that no attempts were made to check the pest that spring, and other duties prevented our getting in a blow at the grubs, as we might have done, during the summer. But the next spring we were on the watch and as soon as the advance guard of the enemy appeared on the swelling buds it found that a dose of poison had been included in its first menu. We had thoroughly drenched every bud with a strong Paris green mixture; the buds will stand the poison at the rate of one pound in 50 to 75 gallons of water, providing an equal amount of freshly-slacked lime is also added. Literally paint the buds with this mixture, and renew the application in a few days, or sooner if rains occur. Any of the other similar arsenical mixtures, like London purple, Kedzie's white arsenic mixture, arsenate of lead, or green arsenite will doubtless prove equally as effectual as Paris green. The measure of success of this method will depend entirely on the thoroughness with which it is carried out. We saved the grape buds the season we tried this spray. The method is practicable and our experience demonstrates to us that it can be made a paying success.

It is thus possible and practicable to successfully combat the pest early in the spring before it can do much damage on the buds. It is only necessary to exercise a little watchfulness and be on hand with your kerosene pan or sheet, or your poison spray, the moment the advance guard of the beetles are seen on the buds. Of course, one should always endeavor to check the pest thus early in the season before it ruins the prospective crop of fruit. But oftentimes it happens that the grape-grower awakens to his danger too late; perhaps he did not realize that the pest was in his midst or he may not understand its habits and life-history. Can he do anything that season to prevent a like destruction of his grape buds the next spring? This is the query we are usually called upon to answer whenever our attention is called to this pest.

Yes, grape-growers can strike a very effective blow at the insect later in the season after the beetles which ate the buds in the spring have practically disappeared. First, the grape-grower must learn to recognize the little brown grubs or larvæ of this flea-beetle, so that he may know what he is to fight. Those fruit-growers who understand what they are spraying for get much more satisfactory results than those who spray simply because their neighbors do.

It should be a very easy matter for the grape-grower to make himself familiar with the grubs of this grape-vine flea-beetle and their work, after reading our discussion of when, where and how they work and how they look. Their work is quite conspicuous (figure 19) and as they usually feed exposed on the upper side of the grape leaves, it is an easy matter to locate them and to hit them on their feeding ground with a spray. Experiments have shown that the grubs readily succumb to a spray of whale-oil soap (1 pound in 6 or 8 gallons of water) or kerosene emulsion; but as these insecticides kill by contact, it is necessary to hit the grubs themselves with the spray. A less expensive and easier method is to spray the infested foliage with Paris green or some other poison, thus poisoning their food. For this purpose the poison need not be used as strong as on the buds to kill the beetles; a pound of Paris green in 150 gallons of water is strong enough to kill the grubs quickly.


19.—*Grape foliage riddled by the grubs of the Grape-vine Flea-beetle; reduced in size.*

We would strongly advise all grape-growers who have this pest to fight to devote considerable of their energy toward killing the little brown grubs of this flea-beetle when they feed on the leaves in June in New York. Why? Because it is these grubs that develop into the beetles which emerge in July, go into hibernation in the autumn, and come forth in the spring to devour the grape-buds. Thus every one of these grubs that is killed in June means one less beetle to nip your crop of fruit in the bud the following spring. Hence it is exceedingly important to kill every grub possible in June. Fortunately, the grubs are easily accessible and readily succumb to the proper spray. We cannot too strongly emphasize this point that grape-growers should make every effort to kill the grubs of this pest in June. The grubs can be fought much more easily and successfully than the beetle.

Oftentimes it will be found necessary to spray only portions of a few vines to kill most of the grubs. This can be readily done with a knapsack sprayer. We believe that by thus spraying their vines in June our New York grape-growers can reach this pest in its most vulnerable place, and at the same time insure their fruit buds from attack by the beetles in the spring.

In brief then, the grape-vine flea-beetle can be easily controlled by the thorough use of a poison spray on the bursting buds in early spring, or the beetles may then be collected from the buds in pans of kerosene or on sheets soaked in kerosene. Follow up this treatment in the early part of June by spraying the vines with Paris green to kill the grubs then feeding on the upper surface of the leaves; every grub killed then means one less beetle to hibernate and attack the buds the next spring. Be sure and kill the grubs in June.

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155. Second Report on the San José Scale.
156. Third Report on Potato Culture.
157. The Grape-vine Flea-beetle.

Bulletin 158. January, 1899.

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

VETERINARY DIVISION.

AN INQUIRY CONCERNING THE
Source of Gas and Taint
PRODUCING BACTERIA IN CHEESE CURD.

NEW YORK STATE VETERINARY COLLEGE

By V. A. MOORE and A. R. WARD.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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CORNELL UNIVERSITY, ITHACA, N. Y., Dec. 7, 1898.
THE HONORABLE COMMISSIONER OF AGRICULTURE,
ALBANY, N. Y.

Sir: This bulletin is submitted for publication under Chapter 67 of the Laws of 1898.

The presence of gas, accompanied by undesirable taints in cheese curd, has long been known to be a potent factor in lessening the market value of cheese.

A few bacteriologists have found that the cause of the gas and taints is a gaseous fermentation due to the presence of certain bacteria. The particular species of bacteria which produce this fermentation have not heretofore been clearly defined; their source or the channel through which they get into the milk has not been definitely pointed out. While, therefore, this trouble has been attributed with reason to bacteria, the definite knowledge of species and of means for carrying out intelligently preventive measures was wanting.

The purpose of this bulletin is to point out one of the species of bacteria which causes this trouble; the channel through which it gets into the milk; and the precautions necessary to be taken in order to prevent its appearance.

It has been necessary to restrict the inquiry to the conditions arising in a single factory and in a single dairy. It cannot be assumed, therefore, that the result obtained can without further investigation be used to explain the cause of this trouble in all factories.

The investigation has brought out in a most conspicuous manner the necessity for a large amount of bacteriologic investigation in determining the effects upon milk, butter and cheese of a large number of bacteria commonly present in the excreta of cattle.

This inquiry has brought out several facts, heretofore generally denied, concerning the source of bacteria in fresh milk. The research demonstrates that bacteria do exist sometimes in the milk ducts of the udder itself as well as in the teats. It is also shown that the same species of bacteria will persist in the udder for a considerable time if once introduced. This is highly important in showing the necessity for cleanliness in cow stables.

The investigation, as a whole, has opened a new field and will without doubt lead, in time, to extremely valuable results. The only regret is that time and opportunity have not enabled the Station to make as extended researches as is desirable. Suffice it to say, the investigation will be continued another year.

I. P. ROBERTS.

DESCRIPTION OF PLATE.

A photograph of a section through the teat and one quarter of the udder of a cow. The parts represented by the letters A. B. C., indicate the three arbitrary divisions into which the gland was divided for purposes of examination.

We are indebted to Dr. G. S. Hopkins for the loan of the excellent museum specimen from which the photograph was taken.

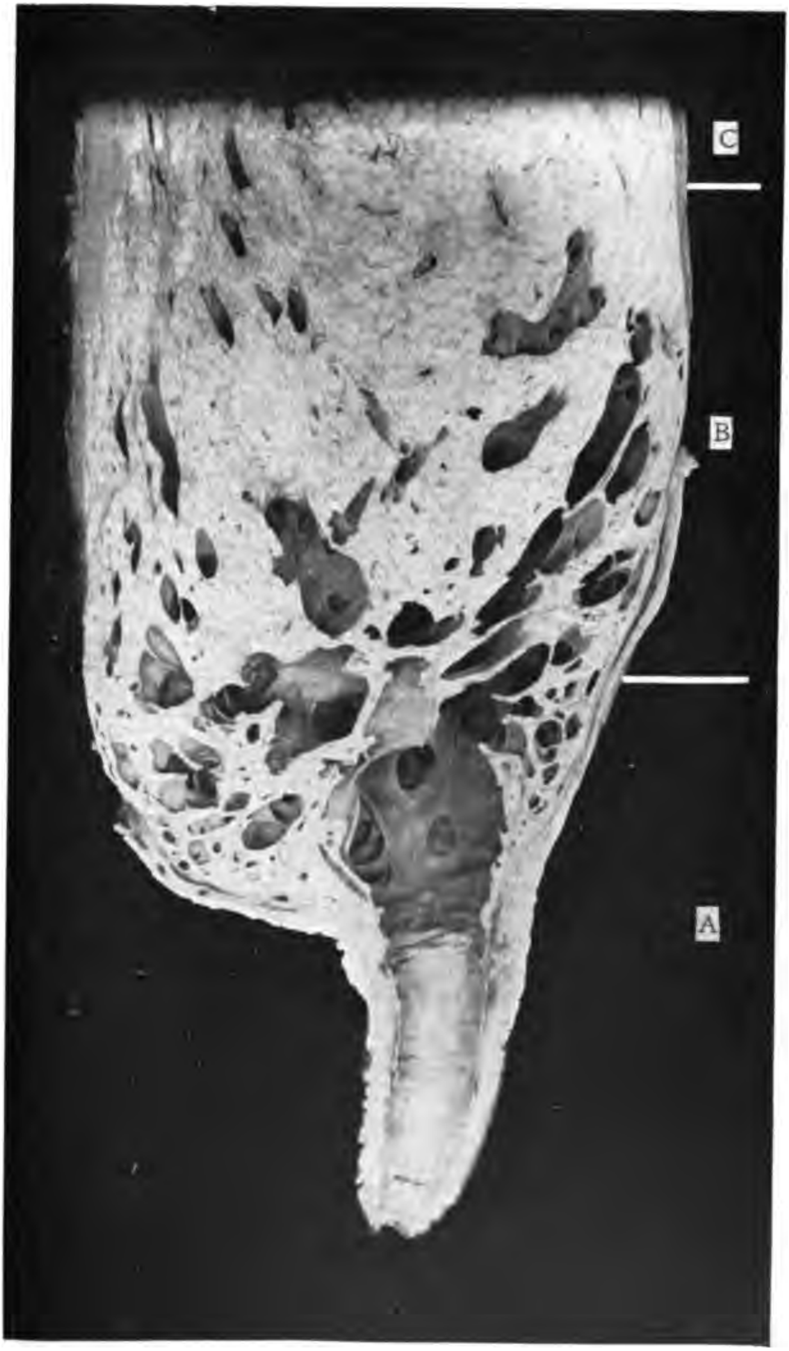

PLATE III.

AN INQUIRY CONCERNING THE SOURCE OF GAS AND TAINT PRODUCING BACTERIA IN CHEESE CURD.

BY VERANUS A. MOORE AND ARCHIBALD R. WARD.

A common trouble encountered by cheesemakers is the presence of disagreeable taints which develop in the milk and curd during the cheesemaking process. Although certain taints, hereafter mentioned, may appear in the milk and curd unaccompanied by the formation of gas, the more common and troublesome ones are constantly associated with, and appear to be dependent upon, a gaseous fermentation. Inquiry has shown that the change in the flavor of the ripened cheese which follows the presence of these bad odors in the milk and in the curd when it is put to press diminishes very materially the market value of the product. Notwithstanding that much of the skill of the cheesemaker consists in his ability to recognize tainted milk when it comes under his control,and to apply measures to prevent the formation of gas, and check or prevent altogether the taints which subsequently arise and give the undesirable flavors, it frequently happens that he is unable to do so. In such cases, the questions which naturally arise, are : What is the cause and who is responsible, the patron or the cheesemaker ? The reason for this two-sided question seems to rest in an uncertainty concerning the specific cause. The patrons find it easy to blame the cheesemaker, and he in turn attributes the cause to agencies outside his factory.

Several explanations have been offered for the occurrence of "gassy" or pin hole curd and accompanying taints. Russell and others have demonstrated experimentally the cause to be the fermentation produced by certain bacteria which get into the milk. Lloyd* has shown that among other things, "a diarrhoea which tends to increase the introduction of fecal matter into milk, is a direct cause." Thus he has pointed out that "certain tracts of the country are not suited to the manufacture of cheese as the excess of certain salts in the soil which are taken up in unusually large quantities by the forage plants, tend to produce a continuous looseness of the bowels." It is well known to American cheese buyers that the most desirable flavors are not found in cheese made from the milk of cattle pastured on certain swampy or new lands. The cause here, is due to the tainting of the milk through the physiologic effect of certain of the plants eaten by the cattle. A familiar analogous illustration is found in the well known flavors imparted to the milk and butter when cattle are fed upon turnips or grazed in a pasture where wild onions are abundant.

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*Journal of the Bath and West and Southern Counties Society, England, Vol. IV, 1894.

Some dairymen in this country believe that the trouble is attributable to certain abnormal conditions attending parturition. This is based on the observation that frequently, if not always, a few cows in one or more of the dairies furnishing milk to the troubled factory retain the placenta or afterbirth at the time of parturition, and that the conditions thus brought about, cause the subsequent odors in the curd made from the milk.

The painstaking investigations of Russell indicate that the cause of the particular odors and flavors in question are of bacterial origin, and that they have nothing in common with those due to volatile or other substances in the food. Guillebeau has found a close relation existing between the bacteria that are able to produce an infectious mammitis and some forms capable of gas evolution. Several times "gassy" milk has been traced directly to animals suffering from an acute inflammation of the udder in which it has been affirmed that the organisms producing the disease were a direct cause of the gas production in the milk. Guillebeau* found three bacilli which he believed to be the cause of inflammation of the udder, and which possessed the power of causing a well marked cavernous structure in the cheese.

In the summer of 1897, an opportunity arose to inquire into the cause of "gassy" curds and taints in a factory receiving milk from a dairy in which there had been considerable trouble from retained placenta. This investigation promised to throw some light upon the relationship of the alleged cause to the trouble. The outcome is not altogether conclusive concerning the possible initiative significance of the retained placentas, but as it offers many suggestions relating to the actual source of the special taints in question, a report of progress seems desirable. This is made the more urgent from the fact that the taints in the milk from this particular factory were pronounced by Instructor Hall, and by others, to be the same as those which are causing the greatest amount of trouble in the factories throughout the State.

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*Quoted by von Freudenreich. Dairy Bacteriology, page 57, English translation by Davis.

In the case in question, the factory was furnished with the milk from two dairies; one of these belonged to the owner of the factory and farm on which it stood, and the other to a neighbor. The dairy on the farm and in which the parturition trouble occurred, consisted of twenty-five cows. During the winter of '96–'97 the cows had been given a heavy grain diet. The animals were housed in a comfortable stable which was kept clean from the standpoint of the present popular ideas of stable cleanliness. They were all in good condition. The factory opened late in March, as early as there was sufficient milk, and the curd was of the finest quality. It so happened a little later, that at the time of parturition, the placenta or afterbirth, was retained by eleven of the cows. As these were not properly attended by a veterinarian, the retained membranes were not removed but allowed to decompose *in utero* and to be discharged. This gave rise to an intensely disagreeable (putrid) odor about the stable. Soon after this happened, the peculiar taints in the milk with "gassy" curd began to appear.

The cause of the trouble was at once attributed to the cows which discharged the retained and decomposing placentas. It was to ascertain, if possible, whether or not this was the cause, that the present investigation was undertaken. Unfortunately, the trouble had been going for several weeks before it came to our notice and, meantime, the affected cows had recovered, but the tainted and "gassy" curds continued to appear and to cause a serious depreciation in the value of the cheese.

In the investigation, it seemed best to begin with the "gassy" and tainted curd to find if possible the specific cause, and then to look for its source. Without entering into the technicalities of the methods followed, the results of a careful bacteriologic examination of the curd showed that both the taint and the gas were caused by the same species of gas producing bacteria, a microörganism resembling very closely, if not identical with, *Bacillus coli communis*. The evidence of the correctness of this assertion is based entirely on the fact that when cheese was made with milk which had been sterilized and then inoculated with this bacillus, that the "gassy" curd and the taint in question would develop.

The factory itself was kept scrupulously clean and the only possible source for the organism there seemed to be in the rennet or in the water used in cleaning the vats. These were both subjected to a thorough bacteriologic test for gas producing bacteria with negative results. This outcome practically eliminated, as was expected, all suspicion that the organism came from the factory. It was then determined by making the milk up separately from the two dairies that the bacillus which was causing the trouble came to the factory in the milk from the dairy on the farm. It remained to be found whether its presence in the mixed milk was due to the dust and filth which invariably fall into the pail from the flanks and udder of the cows at each milking, or, whether it was in the milk ducts themselves, and if so to determine which cows were thus infected.

Cheese was made at our suggestion leaving out the milk of the cows which were reported to have suffered from the retained placenta without, however, any improvement in the condition of the curd. This necessitated a careful examination of the milk from each cow in the dairy. This was made from a series of samples taken daily for a period of two weeks.

The bacteriologic examination consisted in testing for gas producing bacteria, using the fermentation tubes and also the curd test recommended by Russell of the Wisconsin Agricultural

Experiment Station.* Before collecting the samples of milk the cows' flanks, udders, teats, and the hands of the milker were washed with a 1 to 1000 solution of corrosive sublimate. The jars in which the milk was to be collected were sterilized by boiling. The outcome of this series of observations showed the gas and taint producing bacteria to be present more or less constantly in the milk of each animal. In addition to the gas, the curd tests emitted the disagreeable odor. These were invariably present in the test curds made from the milk of certain of the animals while those made from the milk from the other cows were not constantly bad, there being occasionally days in which the taints were less marked or absent altogether.

In the above tests the fore milk was used. The examination was repeated, however, with the milk from several of the cows in which that taken from the middle or latter half of the milking was used. Similar positive results were obtained showing that the rejection of the fore milk from all of the cows would be of little or no use in checking the trouble.

A study of the results obtained from the daily examinations of the milk from the different animals, gave no assurance that the trouble would be eliminated by keeping out the milk from any particular cows. The interesting fact was brought out that the test curds made from the milk of the cows which had suffered from retained placenta were, as a rule, no worse than those made from the cows which had not been so affected. The cows from which the constantly bad curds were obtained were among those which had had a normal delivery.

The positive results obtained in the test with the fore milk, naturally led to an examination of the dust and filth from the floor of the stable. As in the other examinations this consisted simply of a search for gas producing bacteria. Several varieties or species were isolated and studied, but none of them resembled very closely the one isolated from the "gassy" curd although they approached it in some one or more of their properties. After a careful but fruitless search in these substances for this organism the conclusion seemed to be supported that this bacillus was not widely disseminated at that time in the stable. This suggested that the obnoxious organism got into the milk through the teat infection rather than on the particles of dust which fall into the milking utensils. A further argument for the teat infection rests in the fact that after the stable was thoroughly cleaned and disinfected, the trouble continued without immediate abatement. Gradually, however, it began to disappear, and late in the fall it had practically ceased. The constant cleansing prevented reinfection so that when the teats happened to be cleared of this organism they were not again infected with it.

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*Samples of milk placed in sterile vessels are allowed to stand in a moderately warm place for several hours after which rennet is added. Gas producing bacteria will, if present, cause the formation of gas bubbles in the curd, similar to those encountered in the cheese vat. The test is fully described in the Twelfth Annual Report of the Agricultural Experiment Station of the University of Wisconsin, page 148 and in Bulletin No. 67 of the same station.

It has long been known that the fore milk when drawn under aseptic precautions contains bacteria. Their presence is generally supposed to be due to the infection with the bacteria which chance to get upon the end of the teat, multiply there in the remaining drop of milk and gradually grow up on the mucous membrane of the milk duct from which they are washed out during the subsequent milking. The examinations made in the present investigation suggested that the gas and taint producing bacteria had, in addition to this temporary invasion, become colonized in the udders of certain of the cows. This, however, could not be positively determined.

Although the present knowledge of the extent of the bacterial invasion of the udder presumes that it is not extensive and under normal conditions probably does not reach beyond the teats, it seems difficult to explain the results obtained without presuming, as did Gernhardt, that sometimes the bacteria grow up through the teat and cistern into the ducts of the glandular tissue. A few months after this investigation, we had the privilege of examining bacteriologically the udders from several freshly slaughtered milch cows and found that the mammary gland is, sometimes at least under presumably normal conditions, invaded with bacteria. This fact strengthens our belief that in the case of the gas producing bacteria, they had invaded the udder itself and become colonized there. As the results of the bacteriologic examinations of the udders are of special significance in reference to the source of the bacterial infection of milk, a brief statement concerning them seems desirable.

In January, 1898, Dr. Cooper Curtice, inspector for the State Board of Health, invited us to be present at the killing of a herd of cattle which had responded to the tuberculin test. The udders of six cows, all of which were in good condition were carefully examined. The post-mortem examination showed the tubercular lesions to be restricted to a few small nodules in the bronchial and pharyngeal glands. The cows were milked just prior to being killed. Specimens of the fore milk were taken. Each quarter of the six udders together with the milk specimens from each were examined bacteriologically.* The possible criticism that these animals were tuberculous does not seem to detract from the results as the cows were in good condition and the obvious lesions were, as already stated, restricted to a few tubercular foci. After making the cultures the udders were very carefully examined for tubercular or other lesions, but they could not be found. For convenience in noting results the gland was divided arbitrarily into three parts as follows: (A) The lower third including the teat and cistern; (B) The middle third which included the lower half of the gland proper, and (C) the upper third, which included the remaining portion of the gland. (See plate.)

The same species of bacteria† were found in the fore milk, cistern and middle and upper thirds of the udder from each animal. It should be remembered that the examinations were made almost immediately after the cows had been milked dry. In some instances the same organism was found in each part (A. B. C.) of a quarter of a gland, while in others, the bacteria were more irregularly distributed. The cultures made from the tissues from the middle and upper thirds of a few quarters remained clear. In making these cultures pieces of the glandular tissue as large as an average sized bean were used. The number of colonies was small in all cases. However, the essential fact is that bacteria were there and remained there after milking, ready to infect the milk of the next succeeding milking.

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*The methods employed were those ordinarily used in milk analysis. The description of the details and an account of the results of the examination from each individual quarter of the glands are held for a future publication on the bacterial invasion of the normal udder.

† The predominating form was a micrococcus which grew in a yellow or buff colored colony.

During the summer of 1898, a second opportunity for examining two udders under like circumstances was availed of. In these cases the same organism, a micrococcus was found in cultures from the milk and from different parts of the mammary gland. Gas-producing bacteria were not found in any of the udders examined.

The investigations heretofore reported, have not shown, as a rule, the presence of gas-producing bacteria in the fore milk. It is only occasionally that we find in the records of these investigations a statement of the presence of gas-producing organisms. Bolley and Hall* examined the milk of ten cows for a period of three months without encountering gas-producing bacteria. Others have recorded practically the same results. This is significant in suggesting that the normal intestinal bacteria, especially *Bacillus coli communis*, does not under ordinary conditions invade the milk ducts. Likewise, a vigorous gas-producer, *Bacillus cloacæ* which is found in the soil does not seem to become localized in the udder.

It will be seen from the description (p. 234) that the bacillus isolated from the tainted curd is closely related to, if it does not belong in the colon group of bacteria.† The evidence collected supports the hypothesis that the milk ducts were in this case invaded with this organism about the time that certain of the cows were discharging the decomposed placental membranes. As the stable was not disinfected or kept as clean as it might have been, it is presumable that the bacteria which became concentrated in large numbers in these membranes were disseminated throughout the stable, and, coming in contact with the end of the teats, this particular species found a suitable place for multiplying and from there grew up into the udder. The examination of the milk from several animals in different dairies fails to show a common invasion with this or similar organisms. A careful comparison of the bacillus obtained with different cultures of *Bacillus coli communis*, isolated from the intestines of cattle, shows that there is an appreciable difference between the two although not enough to place them in separate species. The facts warrant us in supposing that this particular organism possessed, to an unusual degree, power to invade the milk ducts just as certain cultures of a species of pathogenic bacteria possess more virulence than other cultures of the same species.

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*Centralblatt für Bakteriologie u. Parasitenkunde, Vol. II. Abstract in Experiment Station Record, U. S. Dept. of Agric., Vol. VII., p. 99.

† In the intestines of healthy animals, there is constantly present an organism known as *Bacillus coli communis*. There are many varieties of this species and for convenience all of these varieties are classed together under the general term of the colon group.

It is unfortunate that an examination of the milk of each cow was not made early in the course of the trouble. While it is not demonstrated that this organism was present in the decomposing uterine membranes, it has been shown that bacteria of this group often get into the uterinecavity in casesof parturient difficulties. It has also been pointed out that the colon bacteria, like certain other organisms, may have their properties modified when they are grown under different conditions or environment. It would probably have been possible, had the examinations been made at the proper time, to have determined whether the organism in question made its appearance simultaneously with the discharge of the putrid placenta, and whether or not the cows thus affected were the first to have had their milk contaminated with this species.

It has long been recognized that the species of bacteria in the fore milk are modified largely by the conditions under which the cattle are kept. When on green pasture with little or no opportunity to get into mud or filth, the number and species of bacteria in the milk are much smaller and different than they are when the cows lie in filthy yards or stables.

It is important to bear in mind that when certain bacteria get into the milk ducts of the teat, or possibly in those of the udder itself, there is a tendency to become localized and to remain there for a considerable time, while other species do not take readily to this environment. In the examination of the fore milk from one of the cows of the University dairy, two species of micrococci and one of a streptococcus were found to persist for several months. The examinations made at different times showed first one and then the other species to predominate in numbers. After about eight months, however, the micrococcus disappeared from one quarter, leaving the streptococcus only, but the micrococcus remained in the other quarters. In another animal a staphylococcus has persisted in the fore milk for over eight months. The fact to be emphasized is that certain species of bacteria sometimes do persist in the milk ducts.

The question has often been asked if the bacteria which cause the taint in the milk do not pass through the tissues of the animal from the intestinal tract to the udder. This question has doubtless been suggested by the fact that frequently after the cows begin to drink from stagnant pools, the taints and "gassy" curds begin to appear. The frequent detection in the milk of flavors and odors characteristic of vegetables which the cows have eaten, such as garlic or turnip, may have suggested that bacteria could in like manner pass into the milk. The belief centered in the affirmative answer to this question is so strongly entertained by some dairymen that a word of explanation seems necessary.

Some of the early hypotheses regarding bacteria in the animal body might be construed to mean that such a procedure was possible, but the fact is now well established, supported by the results of many investigations, that bacteria do not pass from the digestive tract to the various glands of the body so long as the animal is in a perfectly healthy condition. This does not imply that such a passage does not under certain abnormal conditions take place, but that it is a common or even a rare normal occurrence, must in the light of our present knowledge, be unhesitatingly denied. The occurrence of tubercle or anthrax bacilli in the milk is not an analogous case, for in these diseases, the bacteria are already within the animal body where they can be carried to various parts by the blood and lymph in their respective vessels.

In order to bring positive evidence to support this reply, two experiments were made to test the power of bacteria to pass from the intestine to the udder. The fore milk of two cows was carefully examined and the normal bacterial content determined.

The cows were then given daily in their drinking water from one to two quarts of a bouillon culture of a *Bacillus prodigiosus*,*and the milk carefully examined but this organism did not appear in the milk although the feeding and examinations were continued daily for nearly two weeks. The experiment was repeated with cultures of the gas-producing bacillus with similar negative results.

From the known facts it is highly probable that the cause of the "gassy" curd made from the milk of cows allowed to drink from stagnant pools is not that any bacteria in such water pass through the animal tissues into the udder, but that the cows wallowing in this water or other unwholesome places, smear the teats and udder with the dirt and filth containing the obnoxious organisms. These bacteria are then either carried directly into the milk on the dried particles which drop into the pail at the time of milking, or else they infect the milk ducts and udder as in the case herein described. There is always left on the end of the teat a small drop of milk in which the bacteria can multiply, and from which they can gradually grow up into the milk passages. In such an infection we have a condition quite similar to the one under consideration.

In the case where the "gassy" curd follows the drinking of stagnant water, it is presumable that a different species of bacteria is the cause. There are a number of bacteria which produce gas and which are found to be widely distributed in nature. How many of these are capable of producing the taint in question is not known, but it is highly probable that several of them could do so. We do not presume the organism we have isolated and studied is the only one to be feared or guarded against. The facts elicited suggest that all bacteria capable of producing a gaseous fermentation in milk, might, if the fermentation process was continued for a sufficient length of time, give rise to objectionable taints and flavors. In our experimental work with the bacillus in question, a considerable variety of taints were detected in the milk and curds. The difference in them depended for their cause upon the length of time the fermentation had been going on. It is not unlikely that this explains in part the cause for the variety of unpleasant taints and flavors detected by cheesemakers and buyers. The cause for the considerable number of taints however, needs further elucidation, but the experience with this particular species of bacteria indicates that our explanation may be found to be correct. Certainly, the economic importance of these disagreeable taints and flavors render a more thorough and general investigation into the causes and means of prevention much to be desired.

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*This organism was chosen as it is easily detected, if present, by the deep red color of its growth on culture media.

SUMMARY.

The results obtained in the investigation herein reported may be summarized in the following statements:

1. The "gassy" and tainted curds were caused by the action of a certain species of bacteria which was present in the milk.

2. This organism was introduced into the milk at the time of milking. It came from the milk ducts of the teat or, perhaps, from those of the udder. There seems to be no evidence that it was carried into the milk with the particles of dust or bits of dirt which invariably fall into the pail unless special precautions are taken to prevent their entrance.

3. The organism is closely related to *Bacillus coli communis*, a species of bacteria commonly found in the intestinal tract.

4. Positive evidence was not obtained to show that the retained placentas, with their subsequent decomposition and discharge, were the cause of the milk duct infection with the micro-organism which produced the gas and taints in the curds.

5. The wide distribution of this organism in the milk ducts of the cattle, and its apparent absence or at least infrequency in the dirt of the stable, indicates that the cattle had been exposed in some way to this organism. It is very likely that the decomposing membranes might have been the channel through which the infection took place.

6. The milk duct infection of all of the cattle in the dairy with this organism was made possible by the fact that the stable was not thoroughly cleaned and disinfected as soon as the trouble with the "gassy" curds and taints began.

7. Certain species of bacteria when once introduced into the udder are able to remain there for a considerable length of time,

thus becoming a constant source of contamination. When this takes place, immediate relief does not follow the cleansing of the stable, but such treatment if continued will probably be efficient.

8. After thoroughly disinfecting the stable and putting it in a clean condition, the milk of each cow should be tested, and the milk of those animals found to be infected should be kept out of the vat until the normal condition is restored.

Prevention.—In the light of the present knowledge of the infection of milk with gas producing bacteria, the best preventive measure seems to be cleanliness, keeping the cows themselves and the stable clean. It is highly important not to have in the stable or about the yard any decomposing animal matter. If there is trouble with retained placentas at the time of parturition, the cows should be properly attended, the membranes removed and disinfectants applied. If these precautions are taken and the same care exercised in cleansing the milk utensils, it is highly probable that a general infection would not take place. Although the method has been reported by a German experimenter, the disinfecting of the milk ducts by washing them out with a suitable germicide through the aid of the milking tube has not been successful in our hands.

The proper care of the animals, the keeping of the stable in a clean, wholesome condition and the occasional use of disinfectants* cannot be too urgently recommended as prophylactic measures.

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* Of the cheap disinfectants the following is very efficient. It is quite corrosive, and care should be taken to protect the eyes and the hands from accidental splashing:

Crude carbolic acid	½ gallon.
Crude sulphuric acid	½ gallon.

"These two substances should be mixed in tubs or glass vessels. The sulphuric acid is very slowly added to the carbolic acid. During the mixing a large amount of heat is developed. The disinfecting power is heightened if the amount of heat is kept down by placing the tub or demijohn containing the carbolic acid in cold water, while the sulphuric acid is being added. The resulting mixture is added to water in the ratio of 1 to 20. One gallon of mixed acid will thus furnish 20 gallons of a strong disinfecting solution, having a slightly milky appearance. The mixture should be applied to the walls and floors of the stable, saturating them with it."

A 5 per cent solution of commercial sulphuric acid can be used. This is desirable as it is free from the objectionable odor of the crude carbolic acid.

A BRIEF DESCRIPTION OF THE GAS-PRODUCING BACILLUS.

Source.—Tainted "gassy" cheese curd taken from the vat and from samples of test curds made from the milk of individual cows in the dairy furnishing the milk.

Morphology.—An actively motile bacillus. In twenty-four hour bouillon cultures the individual organisms are found to vary in length from 2 to 4μ. They have a uniform breadth of 1.2μ. They are single with rounded ends. When stained with carbol-fuchsin or with carbol-methylene-blue they exhibit a marked polar arrangement of the cellular protoplasm. They stain feebly but uniformly with alkaline methylene-blue. Crystal violet stains the whole of the organism uniformly and deeply. It does not retain the stain when treated by the gram method. Flagella are readily demonstrated by Loeffler's method. Spore formation has not been observed. It does not appear to have a capsule.

Biologic Characters.—This bacillus grows readily on all of the ordinary culture media. Its temperature limitations are from 8° to 40° C. It grows best between 35° and 38° C., and at a low temperature its development is exceedingly slow and feeble. It is aërobic and facultative anaërobic.

Agar.—Surface colonies on agar plate cultures grown at 37.5° C. are circular, flat, with regular, sharply defined borders. They vary according to the number present, from 2 to 4 mm. in diameter. They are not viscid, neutral gray in color, with moist glistening surfaces. By transmitted light the color appears to be darker. The plate cultures emit a penetrating odor resembling slightly that coming from cultures of swine-plague bacteria. The deep colonies are grayish, lenticular shaped masses 0.5 to 1 mm. in length. In slant cultures the growth is of a neutral gray color usually spreading over the entire surface of the medium. The condensation water is clouded with an accumulating grayish sediment.

Gelatin.—Colonies on the surface of gelatin plates are thin, spreading, 3 to 7 mm. in diameter, wrinkled, with irregular but sharply defined borders. With transmitted light the centers have an opalescent appearance, these are surrounded with a thinner translucent zone extending to the edge. In gelatin stab cultures, the growth along the needle track consists of a series of isolated or confluent grayish colonies which are more numerous near the surface. The surface growth is spreading.

Potato.—A thin brownish yellow growth first appears. After several days in the incubator it becomes thickened and of a brownish color. It is not viscid.

Alkaline Bouillon.—At 37.5° C. the liquid becomes uniformly densely clouded with the accumulation of a grayish friable sediment which is easily disseminated upon agitation. The reaction is acid during the period of most active growth, but it becomes alkaline in about five days. At this time the sediment has a floculent or fluffy appearance extending up into the liquid for several millimeters. In old (3 to 6 weeks) cultures a thin, grayish pellicle forms over the surface.

Acid Bouillon.—The growth is similar but less vigorous in acid than in alkaline bouillon. The sediment is somewhat lumpy or aggregated into dense masses. If undisturbed, a thin pellicle may form on the surface. The reaction finally becomes alkaline.

Milk.—This organism coagulates milk in about three days, when grown at a temperature of about 37° C. The coagulum contracts and becomes covered with a clear serum. The casein is not digested. It is strongly acid in reaction and gives off a sour odor. Occasionally the taint similar to that in the curds can be detected in 24 hour cultures. It is, however, more noticeable in larger quantities of milk.

Gas production as determined in the fermentation tubes with bouillon containing sugars. (1) *One per cent glucose bouillon* —On the day following the inoculation, the liquid in the open bulb is heavily clouded and acid in reaction. In the closed arm, the liquid is less heavily clouded. In the bottom of the tube there is a considerable quantity of a grayish, friable sediment. Gas is present. The maximum amount of gas is produced by the second day. It occupies $\frac{9}{16}$ of the capacity of the closed arm of the tube.

(2) *One per cent lactose bouillon.*—The liquid in the open arm becomes clouded and acid in reaction in 24 hours. The liquid in the closed arm is more faintly clouded. Gas is present. The

maximum amount of gas produced is ⅜ of the capacity of the closed arm.

(3) *One per cent saccharose bouillon.*—The liquid in the open arm of the fermentation tube becomes decidedly clouded but remains alkaline in reaction. In the closed arm the liquid in the upper part remains clear and that in the lower third becomes very feebly clouded. Gas is not produced.

The analysis of the gas gives the ratio of the gas absorbed (CO_2) by sodium hydroxid to the explosive residue (H) as 1 : 2. This ratio holds true for the gas produced in both the glucose and lactose bouillons.

During the eighteen months that this organism has been under artificial cultivation, there has taken place a diminution in the amount of gas evolved in the fermentation tubes containing the sugar solutions. At present, only about one-fourth of the quantity of gas originally produced is formed.

Thermal Death Point.—This organism is destroyed in freshly inoculated small tubes of bouillon when exposed to a temperature of 60° C. for ten minutes in a closed water bath.

Resistance to drying.—Drops of a bouillon culture placed on sterile cover-glasses under a bell jar, retained their vitality tor sixty days.

Indol reaction.—A strong indol reaction was obtained in 48-hour cultures in Dunham's peptone solution.

Production of the taint.—A quantity of market milk was divided into two equal parts which were placed in the two divisions of a double cheese vat so that each might be made into cheese under identical temperature conditions. To one of these quantities of milk, about 100 lbs., was added two quarts of a 24-hour milk culture of the bacillus. Shortly after adding the culture, a " tainted " odor was observed in the milk of the one vat only. During the process of cheese making the odor in the inoculated vat was observed to become progressively more intense. The curd in this vat became distended with gas to such an extent that it floated upon the whey.

Identical results were obtained during the 1898 session of the Dairy School. The milk used in this experiment was taken from the mixed milk with which the other vats were supplied.

"Gassy" curds or taints did not develop in any of the vats other than the one inoculated. The odor which developed in this vat was identical with that recognized in the vat from which the original culture had been obtained. Mr. W. W. Hall, instructor in cheesemaking, employed by the State Department of Agriculture, identified the taint as the one commonly found in curds where bad flavors subsequently appear in the cheese.

NOTE.—After this bulletin had gone to press we received a copy of Bulletin No. 62, of the Agricultural Experiment Station of the University of Wisconsin, entitled "Tainted or Defective Milks: Their Causes and Methods of Prevention," by Prof. H. L. Russell. The reader is referred to that publication for a more general consideration of the causes of defective milk.

From the Laboratory of Comparative Pathology, and Bacteriology New York State Veterinary College, Cornell University, Ithaca, N. Y.

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39 Creaming and Aerating Milk, 20 pp.
40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
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150. Tuberculosis in Cattle and its Control.
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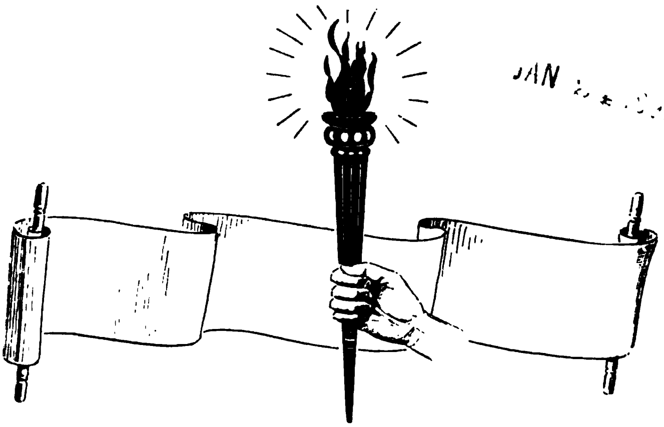
154. Table for Computing Rations for Farm Animals.
155. Second Report on the San José Scale.
156. Third Report on Potato Culture.
157. Grape-vine Flea-beetle.
158. Source of Gas and Taint Producing Bacteria in Cheese Curd.

Bulletin 159. **January, 1899.**

Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

AN EFFORT TO HELP THE FARMER



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Being the Fifth Report to the Commissioner of Agriculture of Progress of Work done under Chapter 67, Laws of 1898 (the Nixon Bill), to Promote the Extension of Agricultural Knowledge.

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1899.

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AN EFFORT TO HELP THE FARMER.

In 1894, the legislature asked the Cornell Experiment Station to endeavor to help the farmers by means of extension work. The request was unsolicited on the part of the University. In the same spirit, the request has been renewed by subsequent legislatures. The gist of the present law is to the effect that the College of Agriculture shall aid the farmer by means of experiments with crops and farm-management, by investigations of special difficulties, by lectures, publications, schools, teaching, and by any other means which promise permanent and useful results. The farmers were thought to be suffering: What can be done for their relief?

The results of much of the work have appeared in 62 bulletins; and full special reports of progress have been made in Bulletins 110, 122, 137 and 146. The present report gives a cursory view of the entire movement; but the details are largely those of the work of 1898 alone. It must be remembered, however, that while the field-work of 1898 is completed, the full results thereof are still in course of elaboration and publication.

Our first effort, in furtherance of the request of the legislature, was to determine what needed to be done. There were many opinions as to the best lines to pursue. We therefore went to the farmers with meetings, schools, lectures, and personal inspection of their places; and thereby we found our bearings. The land-grant colleges had been established for more than thirty years, and the federal experiment stations for eleven years. The results of the efforts of these institutions had been most beneficent, and the general tone of farming had been elevated immensely thereby. And yet, we found it to be a fact that the majority of farmers had not been personally touched by these great enterprises. There seemed to be a lack of actual contact between the farming-body and the teaching-body; and this is due to the fact that much of the teaching and experimenting is necessarily too advanced to appeal to the general farmer. It became plain, therefore, that the purpose of the legislature could be best subserved by teaching the individual farmer in elementary matters. Scientific knowledge is far in advance of even the best farm practice. The farmer must be awakened and educated: how?

I. THE PRESENT-DAY PROBLEMS.

On every hand, the farmer is beset with difficulties. Many of these difficulties are such as pertain to business, or are inherent in the social and economic condition of the times: these cannot be removed by the special teacher or experimenter. Very many of the difficulties, however, are such as pertain to the growing of crops and the raising of stock; to many of these we have given attention.

a. BULLETIN WORK.

By special investigations on the farms and at the central Station at Ithaca, an effort has been made to understand the nature of a given problem: then the summary conclusions are reported in an easy, readable, expository bulletin, in which graphic and truthful pictures are made a special feature. These bulletins are not mere essays. Every one of them has been the result of careful investigation and study by an expert; but, in most instances, the details of the investigational work have been omitted in order to relieve them of heaviness and technicality.

The usefulness of a bulletin often depends quite as much upon its attractiveness as upon its subject-matter. A "dry" bulletin does little good to most farmers, even though its teachings are of the utmost importance. The bulletin should be well printed, handsomely illustrated, and, above all, well edited. It should be timely. The effect of many a good bulletin is nearly lost because it is delayed until the need for it has passed. It must be remembered that the experiment stations exist to help the farmer, not the scientist.

Although this extension work has drawn heavily upon the time and strength of the staff, bulletins from the regular federal fund have been as numerous as they were before the Nixon law was enacted, considering the fact that the income from the federal fund is $1500 less than it was then. From the beginning of 1894, 36 bulletins have been issued from the general federal fund.

Fruits.—The fruit interests received the first attention, because the original act of the legislature so requested. There was also great fitness in this, because these interests are relatively new, they are beset by many special difficulties, and there is a strong tendency to forsake the old-line farming for fruit-growing. There is also a rapidly growing demand for instruction in such special businesses as flower-growing and glass-house gardening. In a preliminary and educational way, nearly the entire field of New York fruit-growing has been worked over ; and thenceforth the fruit-farmer needs new instruction in special problems rather in the great underlying principles. Two of the horticultural investigators have been to Europe (at their own expense) and have made particular studies of similar problems there ; and the New York fruit-grower has had the benefit of these observations in bulletins and lectures.

Of bulletins relating to fruit-growing interests, including insects and diseases, 35 have now been issued under the Nixon bill. Some of the subjects are as follows :

Hints on the planting of orchards.
The cultivation of orchards.
The peach industry in New York.
Grape troubles
Grafting of grapes.
The quince.
Failures in apple-growing.
Blackberries.
Raspberries, and evaporating them.
Plums in New York.
Japanese plums.
Strawberries.
Dwarf apples.
Apricot-growing.
Cherries
Care of fruit trees.
Soil depletion in orchards.

Insects, fungi.—Special efforts have been made to check the spread of the most injurious insects pests and plant diseases. Experts have been sent to investigate serious outbreaks. Orchards have been sprayed, mass-meetings have been called to give instruction in spraying, and much literature on the subject has been circulated.

Of separate bulletins in this direction, 16 have been issued. Some of the subjects are the following:

Peach yellows.
Black-knot of plums and cherries.
Plum scale.
Spraying (several reports).
Cigar case-bearer.
Climbing cutworms.
San José scale (two bulletins).
Diseases of potato.
Diseases of pear.
Quince curculio.
Canker-worm.

Vegetables, flowers. — In vegetable-gardening and flower-growing, 14 separate bulletins have been published, some of which are:

Lima beans (two bulletins).
Celery.
Winter muskmelons.
Chrysanthemums (four bulletins).
Sweet peas.
Forcing-house miscellanies.
Planting of shrubbery.

Sugar beets, potatoes, fertilizers. — Extensive experiments on sugar beets have been undertaken, as reported in Bulletins 143 and 146; and another bulletin is now ready for the printer.

Potatoes are now receiving attention. Bulletin 113 considers the diseases of potatoes. Very striking results have been obtained with the cultivation of potatoes on the Cornell farm, but the reports have been published from the regular Experiment Station fund. (See Bulletins 130, 140 and 156). As explained farther on (p. 248) these experiments are now to be extended over the State.

Extended experiments on fertilizing the land have been conducted during two years, beginning with the issue of Bulletin 129. Experiments of this kind mature very slowly, but forthcoming bulletins will give full results of the work.

Animal industry.—The results of investigations into the cause of "gassy curds" in cheese are published in Bulletin 158. Other subjects pertaining to the dairy and animal industry have received attention, and the results are now practically ready for publication.

In general.—The popularity of the bulletins has exceeded all expectations. New editions have been made of several of them, and three (Nos. 119, 120, 121) have been reprinted five times. Our mailing list is frequently revised in order to cut off all dead and dormant names. The list is a "live" one; and yet of the 62 Nixon bulletins, 907,000 copies have been issued, comprising 679 illustrations and 1880 pages.

b. UNPUBLISHABLE WORK.

Only a part of the work of any Experiment Station can be published. Perhaps half its energies is consumed in correspondence, giving personal advice, attending meetings, making records, and the like. Nor is it desirable that all its experimental work be published, particularly if it is conducted in different parts of the State. The value of an experiment often lies in the fact that it is an object lesson, and that it sets the people of any community to thinking. An experiment in fertilizing potatoes, for example, may be of the greatest value to a community and yet not produce results which are new to science and worthy of publication. The experiment, in other words, may have inestimable teaching value. The farmer may read that spraying is necessary. He may even understand how to perform the operation. But he really does not believe in it until he sees it done and watches the results. If the bulletin is a means of conveying information to the farmer, certainly the itinerant experiment is another means. In fact, the experiment may be the more efficient means; but it cannot be taken to so great a number, and it is relatively much more expensive.

Of all the means of reaching the grown-up farmer, the personal visit to his place is the most efficient. He has a hundred questions in mind. Some of these are settled for him when the Experiment Station officer comes. He looks forward to the visit; and then he looks back upon it and is conscious that new ideas have taken possession of him. He has been touched, and farming will never be quite the same to him thereafter.

This personal contact of teacher and farmer is one of the best results of our scattered experiments with sugar beets and fertilizers. The inspector goes to see the experiments; but he knows that many other questions will come up. For example, our agent who inspected the fertilizer plots, carried litmus paper for the purpose of testing acidity of soils. During the past season, he made 179 such tests; of these, 154 gave decided acid reactions. The nodules on clover roots, the way to make Bordeaux mixture, how to drain a field, what is the matter with a cow, why the hens do not lay, the value of a new strawberry, how to handle a weed,—the questions are legion. The inspector will not be able to answer them all, but he can answer some of them. But, better than answering, he can suggest how the farmer can find out for himself.

It is a pity that every farmer in the State cannot be personally touched at least once in his life by the methods and the inspiration of a good teacher. One section of the State could be taken at a time, and a patient, quiet, honest, sympathetic teacher could visit every farm for a few hours or a day. It would pay.

C. INVESTIGATIONAL WORK NOW IN HAND.

The investigational work comprises experiments proceeding at Ithaca, and also in many parts of the State. Some of these, as fertilizer studies, are long-time subjects, and cannot be reported in full at the close of the first or second year's work. Of several of these investigations, reports may be expected during the present winter. Many minor investigations are not mentioned here. They are such as are of very secondary importance or which apply only to limited areas, or which have been taken up at the request of some local society or organization.

Sugar beets.—In accordance with arrangements made with the State Department of Agriculture at Albany, and the State Experiment Station at Geneva, the Cornell Station conducted experiments in 1898 with sugar beets in the following counties: Niagara, Orleans, Monroe Genesee, Livingston, Wyoming, Erie, Chautauqua, Cattaraugus, Allegany, Steuben, Chemung, Tompkins, Tioga and Broome. In these counties, 1,113 pounds of beet seed were distributed to 417 farmers; and 21 one-pound lots were distributed to applicants outside these counties. Thereby, 438 farmers were connected with the work, and 1,134 pounds of seed were distributed. Of these farmers, 40 received fertilizers for use on the beets, 45 sacks having been used in this distribution. The sugar beet expert visited about 120 of these farmers to arrange in person the preparation for the experiments. Subsequently, he inspected 125 of the growing plots. Aside from this, about 50 commercial plantations were inspected.

Two circulars were issued to the sugar beet experimenters. One (No. 15) explains in detail the methods to be employed in raising the beets. The other (No. 17) gives instruction in methods of sampling, and was accompanied with blanks for the reporting of the results of the work. These circulars will be given to the public in the forthcoming report on sugar beets.

The chemical work on this sugar beet investigation has been heavy. A total of 490 complete analyses has been made, comprising determinations of solids, sugar in juice, and purity.

Experiments are in progress on the feeding value of sugar beet waste.

The full report of the work of 1897 on the sugar beet was published as Bulletin 143. A bulletin will soon be issued on the work of 1898.

Fertilizers.—In 1897, 203 farmers coöperated in field experiments with fertilizers (see Bulletin 146, p. 639). In 1898, 100 farmers were selected to continue the work. In March, a circular (No. 13) was sent to the correspondents, giving specific directions, with diagrams, for carrying on the work. This instruction was supplemented by another and very explicit circular (No. 14), which also included blanks for the making of reports. A revision of Bulletin 129 ("How to conduct field experiments with fertilizers") was also sent to each correspondent.

The 100 experimenters live in 39 counties and 95 postoffices. During the past summer, the fertilizer expert visited 75 farmers at 69 postoffices in 25 counties, and gave specific instructions on the work.

Whenever it seemed to be necessary, samples of soil were taken for analysis. Of these, 38 samples are now being analyzed. In the fertilizer work, there had been made to December 10, 1898 :

76 determinations of nitrogen.
42 determinations of total phosphoric acid.
42 determinations of total potash.
14 determinations of potash by official methods.
14 determinations of phosphoric acid by official methods.
14 determinations of available potash in soil.
14 determinations of available phoshoric acid.

Experiments on some of these soils, with growing plants, are now proceeding under glass.

It is expected that the results of this two years' work with fertilizers will be published during the present winter.

Aside from these general fertilizer investigations, the Horticultural Department has been making similar studies along special lines for a number of years ; and the results now await publication. This undertaking has also involved much chemical work. These investigations have been made in

Nurseries.
Vineyards.
Apple orchards.
Peach orchards.
Strawberry plantations.
Currant bushes.
Field beans.
Celery.

Potatoes.—Such remarkable results in potato growing have been secured during the past three or four years on the Cornell Experiment Station grounds, that it has been thought desirable to test the methods employed here to ascertain whether they will give similar results on other soils and in other hands. It is hoped, also, by having the tests made by the farmers themselves on their own farms, to attract the attention of potato growers throughout the State, more emphatically than it has been possible to do by the work done at the Station.

The land used for these experiments at the Station is a gravelly soil which analysis has shown is carrying little more than half the potential plant-food found in average soils. (See Bulletin 130, p. 157.) It has not been manured or fertilized since the autumn of 1893 (see the same, p. 157), and has produced heavy crops of grain or forage each season till planted to potatoes. (See Bulletin 135, pp. 277, 287.)

In 1895, eight plats averaged at the rate of 352.6 bushels, ranging from 304 to 415 bushels, according to treatment. That year was especially favorable for potatoes and the average for the State was extra high, being 122 bushels per acre. (See Bulletin 140, p. 389.)

In 1896, nine plats averaged at the rate of 319.4 bushels, ranging from 245.8 to 350.3 bushels. The average yield of potatoes in New York for that year was 89 bushels per acre. (See Bulletin 140, p. 389.)

In 1897, ten plats averaged at the rate of 322 bushels per acre, ranging from 234 to 384 according to treatment. The average in the State for this year was 62 bushels per acre. (See Bulletin 140, p. 390)

The experiments of 1898 were similar to those of 1897, and are described in Bulletin 156. The average yield of eleven plats was 292.3 bushels, ranging from 206 to 398.6 bushels, according to treatment.

A circular (No. 18) has now been issued, asking for volunteers in potato experiments. So far as possible, these investigations will be given to those who have taken active interest in the Reading-Course. Favorable responses are now coming in.

Beans.—The field bean interest in New York is very large The Horticultural Department has made some study of it in previous years (p. 248),and it is now proposed to take up the subject more actively. During the past season, a preliminary study has been made of the subject. Pot experiments are now in progress under glass to determine if soil needs to be stocked with specific bacteria in order to produce beans.

Dairy.—During the year, a full investigation has been made of the causes of gassy fermentations in milk, and the results have appeared in Bulletin 158.

Complaints having been made of poisonous cheese coming from a certain factory, the matter was investigated in connection with the State Department of Agriculture. Our cheese maker and bacteriologist were sent to the factory. As soon as our cheeseman took the cheese-making in charge, the poisonous product ceased. The causes of the infection, while not thoroughly understood, are sufficiently known to enable us to publish a report on the subject before spring.

A rather full survey has been made of the condition of the creameries and cheese factories, and the results now await publication in bulletin form (page 254).

Very extensive tabulations of the results of dairy work at Cornell are now being completed, and the summary results may be expected at no distant day.

Veterinary science. — The State Veterinary College now has under investigation, for the Nixon bill, the causes and treatment of contagious abortion in cows.

Horticulture.—Experiments in the fertilizing of strawberry fields have been progressing for three years in Oswego County, and it is designed that they be continued. Preliminary results may be published the present winter. Other experiments with fertilizers are now practically ready for reporting (page 248).

For two years experiments have been conducted in Orange County to determine if celery can be profitably grown on the extensive bottom lands which were formerly used for onions. It has been demonstrated that celery can be raised there with success.

All the extensive fruit interests of the State have been and are constantly under review, and special reports may be expected from time to time. A general review of the fruit-growing business, drawn from long-continued observations in this country and abroad, has recently been published as Bulletin 153. Inspection of orchards for yellows and other diseases, and the giving of personal advice wherever requested, have always been prominent features of the horticultural work.

At Ithaca, the study of Japanese plums (on which three Bulletins have now been issued) is to be continued. A very large collection of these fruits is now growing on the University ground. Studies are also progressing in pruning and on the fertilizing and tilling of fruit lands. Upon this subject of tilling, three or four reports have already been issued, and others may be expected as the tests mature.

The winter forcing of strawberries was reported in Bulletin

134, this being the only bulletin on the subject which has yet appeared in this country. The experiments are continuing, and another report is forthcoming. The subject of forcing-house crops has awakened so much interest, that experiments are now in progress with the forcing of peaches, apricots, nectarines, pears and apples.

A particular study of mushroom growing has been in progress for two years.

In flower-growing the investigations have been rather extensive. These inquiries have two general objects,—to give information to commercial flower-growers, and to interest the people in home-making. The latter purpose is further discussed in Part II.

Chrysanthemum culture has now received attention for five years, and four bulletins have been issued. Another report may be expected soon. Annual flowers have received attention for two years, over 400 species and varieties having been grown. A bulletin on the subject (No. 161) is now on the press. Dahlias, sweet peas, bulbs, carnations and other flowers, are or have been subjects of special investigation.

Extended tests have been made of sweet corn, Brussels sprouts and other vegetables; and some of these are still continuing.

Other horticultural work is considered in Part II.

Insects.—Nine special bulletins have been published by the Entomological Department in the Extension work, and the Department has rendered valuable aid to the work of the Horticultural Department and others. Inspection of infested plantations is a very important part of the work and many minor insects are constantly under review. Aside from this work, the following subjects are now receiving particular attention:

Study of the peach-tree borer. This work has been progressing four years on a plantation of 450 trees set for this particular purpose. The compilation of the results will be completed before spring opens.

Canker-worms. In western New York, about 4000 acres of apple orchards were stripped by these pests in 1898. At least five different kinds of canker-worms are working in these orchards.

Tent caterpillars. Of these pests there are two species, the apple-tree tent caterpillar and the forest tent caterpillar. The latter often works with the former in apple orchards, but it is chiefly confined to woods, often defoliating sugar bushes.

Studies of insects preying upon shade trees in cities and villages.

Plant diseases. — Several bulletins and parts of bulletins have already been devoted to diseases infecting crops. Plantations are inspected by the mycologist. During the past season there has been an unusual correspondence relative to onion and celery diseases, leaf-curl of the peach and blight of the pear. In addition, the following special topics are now under investigation :

The three most important fungous diseases of the sugar beet in this State will be discussed in a bulletin now almost ready for the printer. Beet rot has received special attention and interesting results have accrued, showing the connection of this fungus with certain diseases common in the greenhouse.

A rot of greenhouse tomatoes has been the subject of considerable experimentation ; and experiments now in progress will doubtless complete a determination of the conditions which induce the disease.

Spraying peach trees for the leaf-curl has yielded satisfactory results ; and the whole matter of the effect of Bordeaux mixture on peaches, plums, etc., will be discussed in a bulletin to be published in time for the direction of fruit-growers in 1899.

Chrysanthemum rust, dracæna leaf-blight, and a blight of seedling red cedars, have received special attention among the diseases of ornamental plants.

d. ITINERANT TEACHING.

Aside from all this work of investigation and publication, the people have requested instruction by teachers who shall be sent into their community. In the early days of the Extension work, many such schools were held, and they are fully reported in Bulletins 110 and 122. At the time, these schools were looked upon as means of determining the needs of the farmers and the most efficient methods of reaching them. The officer in charge of these schools reported as follows in Bulletin 122: "As a result of the holding of many of these schools, I am now of the opinion that they cannot be used as primary factors in university extension; they are capable of accomplishing a great amount of good when the community has been awakened by simpler and more elementary means. I should therefore consider that they could serve their best uses when they are given as a reward to those communities in which the greatest amount of interest in reading courses, in horticultural clubs, institutes and such other public factors has been developed. There are centers enough in New York State where such schools can be held with distinct advantage at the present moment; but they should be the culmination of a series of extension teaching efforts rather than a primary or preliminary means of awakening the rural communities."

With this sentiment we still agree. The larger part of our work can be done more economically than by the holding of schools. Yet, these schools are of the greatest value in particular places and cases. During the present winter we have decided to hold ten of them, locating them, so far as possible, in places in which the Reading-Course has made some progress. At this writing, four of these schools have been held, in Niagara, Saratoga, Cattaraugus and Genesee Counties.

In these schools, an attempt is made to teach the fundamental principles of the given subject,—that is, to educate the participants. One session is devoted to one topic, and this is placed in the hands of an expert in that subject. These schools do not in any way conflict with the Farmers' Institutes, but are rather supplementary to the work which they are doing. We believe that the Institutes have done and are doing the greatest good to the farming interests, and the itenerant schools are in no sense rivals of them.

Special dairy schools have also been held during the past summer in factories at Ox Bow, Somerville, Hannibal, Houseville, Carthage, Windecker, McGraw, Windsor, Lyons, Willink, North Cuba, Canisteo and Belfast. These were largely in the nature of practical demonstrations.

A dairy instructor was also sent to cheese factories and creameries in the following counties: St. Lawrence, Franklin, Clinton

Washington, Montgomery, Oneida, Onondaga, Cayuga, Broome, Chenango, Cortland, Steuben, Alleghany. About 75 factories were visited. A report upon these factories will soon be published in bulletin form (see page 250).

Aside from these schools and inspecting tours, the members of the staff are in demand as lecturers before various rural societies and meetings. Such demands consume much time and energy.

II. THE RISING GENERATION.

"My ducks are dying. Please tell me what to do." This is the gist of an inquiry received at the Experiment Station a few days ago. This type of appeal is common, and of course we cannot help the questioner. The difficulty is that the person does not observe closely, does not search for causes, does not see the world intelligently. He does not know a duck ; or if he thinks he knows it, he does not see it. All this failure is the fault of his early training : the person was not educated.

However much we may experiment and teach the farmer, we are not striking at the root of the rural problem. We must begin with the child. Teaching the grown-up farmer is productive of great good, but the crop of grown-up farmers is constantly recurring. The time to educate is when the person is young. Education is then more efficient and cheaper. The first course in our chimney should be laid at the bottom, not at the top.

As the result of five years of effort and enquiry, we now believe that we should endeavor to help the farmer in every way possible in his present-day difficulties, by means of experiments, investigations, bulletins, itinerant schools, institutes, inspection of his place, but that the greatest and most persistent effort should be expended in training the rising generation. The only complete and permanent success is that which takes hold of the very root of the difficulty.

We assume that every one will agree with this proposition. The only discussion will come on the means of touching the rising generation. How shall we reach the children? To this question we have given much thought, and every scheme which has been suggested has received careful consideration. Our conclusion is that the most efficient way of reaching the young is through what we call nature-study.

It is commonly said that agriculture should be taught in rural schools. This may come in time with the older scholars; but the first thing to be taught is how to see, how to reason from what one sees, and to love and appreciate the natural world. That is, the first thing is a training nature-ward; later the training may be applied to specific problems, to farming. Again, there are very few teachers who are competent to teach agriculture in the common schools, even if they had a good text-book. We must teach the teacher as well as the pupil. Still again, the primary school is not the place in which to teach trades and professions. We do not teach law or medicine or engineering in the common schools: these are subjects to be taken up after the pupil has had good mental training. There is little use in telling a pupil about duck-raising until he knows a duck.

In the hands of most teachers, the teaching of agriculture would be instructing in mere ways of doing things, but this is only the giving of information; it is not education. How to plant potatoes, when to cut corn, the best variety of wheat,—these matters do not interest children particularly, and they are different for every different year and locality. The real things to teach are why potatoes should be planted so and so, why corn should be cut at a certain stage of its maturity, what are the principles which underlie the selection of a variety of wheat. These matters are fundamental in every season and in every locality. The pupil is taught to think out the problem for himself. But where are the teachers to do this work? Certainly not in the country schools, for the country schools have the poorest teachers.

a. NATURE-STUDY.

The outgrowth of our present nature-study methods from the itinerant schools of horticulture and the visiting of rural schools, is set forth in Bulletins 122 and 137. The nature-study work is progressing along several lines, each of which may be mentioned.

Leaflets.—In order to interest and instruct teachers in the objects and methods of nature-study the following leaflets have now been issued :

1. How a squash plant gets out of the seed, 5 editions.
2. How a candle burns, 6 editions.
3. Four apple twigs, 6 editions.
4. A children's garden, 7 editions.
5. Some tent-makers, 7 editions.
6. What is nature-study, 6 editions.
7. Hints on making collections of insects, 3 editions.
8. The leaves and acorns of our common oaks, 5 editions.
9. The life-history of the toad, 4 editions.
10. The birds and I, 4 editions.
11. Life in an aquarium.

The number of editions is some indication of the popularity of these leaflets ; but a better measure of their usefulness is shown by the fact that 22,000 teachers have made written requests for them, and 2,816,000 pages of nature-study leaflets have been printed. Aside from this, there is a demand from other States in larger lots,and these our printer is authorized to supply at low rates. He has sold about 5000 copies in 33 States and Provinces.

Applications for these leaflets are now coming in at the rate of about 250 a week. The following table shows the number of requests received for the leaflets for the 10 weeks ending Dec. 10, 1898 :

											Total.
Monday	51	39	63	45	26	28	29	27	46		
Tuesday	51	29	37	32	41	31	24	18	28		
Wednesday	61	40	55	39	15	35	37	54	28		
Thursday	36	21	49	15	94	41	38	17	17	300	
Friday	31	34	23	43	56	57	69	11		37	
Saturday	32	46	25	38	32	25	38	176		61	
	262	209	252	212	264	217	235	303	119	398	2471

Other leaflets are in preparation. However, it is not our purpose to issue a great number of subjects, but to press home every leaflet to the full possibilities of its usefulness. By personal work with teachers, and by correspondence with school officers, tachers and pupils, these leaflets are brought to the attention of those for whom they are written. In this effort, 80,000 circular letters have been distributed.

Following is a sample letter to a teacher :

Egg-shell farming is a very fascinating method of interesting lower-grade pupils in plant life. Egg-shells from the breakfast table are available for the purpose. If broken well towards the small or taper end of the egg, greater capacity for earth and root-growth will be afforded. A small hole should be made in the bottom of the shell, for drainage. Potting-earth from the florist's will probably be the most available source of supply for schools in densely populated districts. Whenever practicable, field excursions for such a supply will add much to the interest of the pupils, and the opportunity for observation can be made of great value as well. Any bit of woods or thicket, where the wind has for years driven the leaves and left them to rot, gives good material for this purpose. Rotted leaves mixed with soil should be chosen, and not rotted leaves alone. We suggest that the child be instructed to fill the shells with soil and plant the seeds, for the more he does in the undertaking the greater will be his interest. He should be made to understand that the shells he fills and plants are his farms, and he must write his name on them for identification. After being filled, planted and labelled, the shells can be massed in a window-seat for watering and light. They can be distributed to the desks of the owners for study and admiration whenever the teacher desires. The spirit of emulation for best results in plant growth can be engendered among all the egg-shell farmers. The question of the number of shells that shall be allotted to each pupil can be left to the discretion of the teacher. The variety of seeds that can be sown to advantage is very general, but if the teacher feels the need of aid in the undertaking, we suggest that squash seed be planted and that our Leaflet No. 1 ("How a squash plant gets out of the seed") be consulted. The fact that the capacity of the egg-shell will not take the plant to maturity need not be deplored. Children like change, and the life-history of nearly all plants covers a period too long for maintaining a juvenile interest on a high key. It is better to have change and to carry on the study by sections. Logical connection is more practical in the higher grades.

If for any reason you are disinclined to take up any feature of nature-study, and you have some pupils who have such a desire, we will appreciate the courtesy if you place us in communication with them for correspondence.

Home-making.—Some of these leaflets are designed to appeal to the home as well as to the school. It is the attractive and happy rural home which first and chiefly interests the child in rural life. A neat lawn or a flower-bed is more likely to influence the child to love country life than a good field of potatoes is. Predilections are formed earlier than we are aware. Money considerations do not appeal strongly to the child. He must be interested on his intellectual and sentimental side. His eyes must be opened to the great world of interesting things all about him; for most persons "have eyes, and see not."

In this work of appealing to the home-making, we have issued various bulletins of which the chief is No. 121, "The Planting of Shrubbery." This bulletin has now gone to five editions, and the demand for it is still brisk. All our flower bulletins (page 244) are also designed to encourage the upbuilding of attractive home life. In furtherance of this idea, the Horticultural Department has been making an extended study of annual flowers for the past two years, and the results are on the press as Bulletin 161.

If the home should be attractive, so should the schoolhouse be. It is a marvel that all the children do not run away from the average rural school premises in sheer dread and disgust. Suggestions for improving these premises are contained in Bulletin 160, which is now nearly ready for distribution.

Organizing the children.—Every incentive is given the pupils to take up observation lessons and collecting for themselves. An efficient means to this end is some kind of an organization of the children. We are now attempting the organization of "Junior Naturalists' Clubs" in all school districts which take an interest in our work. The children write us, enrolling their names, and suggestions are sent them as to the proper work of such a club. We are just beginning this work, athough 6000 children in the State have been reached, and the list is growing rapidly. It is inspiring.

The following sample letter will convey an idea of the kind of work suggested to the children:

ITHACA, N. Y., Oct. 10th, 1898.

My Dear Boys and Girls:

You ask us how to become a member of our Cornell Junior Naturalists' Club.

In answer we would say that we want to begin in a very simple way. We presume that you are in a school and have a teacher who is willing to help you in every way that she can consistent with her school duties. Please ask her if there are not some other boys and girls in your school who also wish to become members; and if so, ask permission to bring into the schoolroom some tent caterpillars or some pollywogs, as are described in our Leaflets Nos. 5 and 9. You can watch them every day. You will find that the hairy fellows which live in a tent have great appetites, but you must study their habits and learn how to feed them. You can watch them enlarge their tents as they require more room, and cast off an old suit of clothes when it becomes too small. You will also find it interesting to watch the polly-wogs develop their feet and lose their tails, and become hop-toads. Ask your teacher to allow you to make all the interesting things that you see the topic for your language lesson, and also for your drawing, if drawing is taught. You can send your papers to us and we will send you similar papers from other Clubs, and will consider you all members. If our talk in Leaflet No. 4 has inspired you to plant some seeds, you can tell us of your progress in that direction, also. This is not all that we intend to make of our Clubs, but this will be an easy way to make a beginning and to become acquainted. We desire to develop your ideas and power of observation more than your spelling and punctuation. When you have learned to think and to see what you look at, you will be better able to correct your English. Please do not feel afraid of us, but write us as you would to an old friend of whom you are very fond.

The problem of providing suitable literature for teachers is small as compared with getting them to take up the work. The horse is easily led to water, but it is not always easy to make him drink. The introduction of the Junior Naturalists' Club, which consists largely in exchange of written observations and drawings, has proved one of the best methods of inducing the teacher and children to make a start. The first step is the hardest. Some rural schools took this first step by gathering apple twigs and sending them to the children of much less favored schools. When the twigs were being packed, they were looked upon as brush; but when a capable teacher had brought out the points as contained in Leaflet No. 3, entitled "Four Apple Twigs," and the pupils had written compositions and had made drawings of what they had discovered and these had been sent to the donors, it was senseless brush no longer. It had a history of half a dozen years written upon it; and it was the old, old story,—a struggle for existence and the survival of the strongest.

More than 16,000 school children in this State have sent us their names in request for information on making gardens; and we have supplied them.

We should like to make it possible for every rural school to have a collection of insects; and for every schoolroom to be embellished with artistic pictures of farm scenes and farm homes.

Personal work at the Teachers' Institutes. — The greatest results are secured by means of personal work with the teacher. In this enterprise, as in others, the Department of Public Instruction has efficiently seconded our efforts. An expert nature-study teacher has been employed to attend Teacher's Institutes. Since the middle of last March, when the present law went into effect, this teacher has attended 72 institutes, occupying an average of three periods in each. It is estimated that 14,400 teachers have been reached in this way. The teacher not only presents the claims of nature-study, but also the specific means by which it may be taught. Many teachers have a mistaken idea as to what constitutes nature-study. Some conceive it to be a translation or exaltation of the child's mind to such an altitude that he can be crammed with science from a book and retain it in such form as to be capable of giving a reflected light in examinations. Examination seems to be the test of the value of all things educational. Our conception of nature-study is that it should be so informal as not to admit of systematic examination. The central thought is to study the thing itself. Each day try to see something that was unseen the day before, and with every new thing ask the question, What does it mean and what is its function? Some examples of nature-study work are now given to show the possibilities of this type of teaching:

The head of a burdock can be picked up. Perhaps the hooks were never before closely examined. Describe them minutely and make a drawing of the seed and hook. Of what use is the hook? When a child learns the functions of parts of vegetable and animal life, the keenest interest is incited. After the children of Corning had made collection of seeds and classified them upon their methods of dissemination, no hard drill was required to learn the names. After a boy has read "Robinson Crusoe" his geography of the island of Juan Fernandez is very accurate or easily acquired. Interest is the first point. No child is proof against the charm of a story. In the lower grades, the study of the things themselves may be idealized and personified. This can be overdone and made mere sentimentalism. Personification is necessary to kindle an interest, but it need not always be continued. As the child grows older and his powers of observation and reasoning become trained, the process can be intensified so that by the time the intermediate grade has peen passed he will be practically studying pure science. Our observation is that, in the graded schools, we get the most spontaneous work from the fifth, sixth and seventh grades.

Nature-study is not the teaching of science, not even of elementary science. It is seeing and understanding the common objects of the external world. The high school pupil and the college student may study botany; but the child should study plants. It need not necessarily be a stated part of the curriculum. In fact, with a good teacher it is all the better if it is spontaneous.

Nature-study can often be made a corollary of the geography, drawing, or language. For example, during the language period, the children in the sixth grade of one of the Saratoga Springs schools had some of their nature-study work for the topic of their compositions. In this instance wheat had been sown in egg shells, filled with earth obtained at the florist's, and each egg shell was a pupil's farm; and he eagerly watched the germination of the seed in his wheat field until the blades had attained a height of two to three inches. Here the botanical side was made a lesson, well flavored with active interest. The pride of ownership and a plant coming from a spoonful of earth had the charm of a creation all his own, and it was much more real to study the thing itself than to read about it and to make a recitation. The lesson was well inculcated that the first shoots of root and stalk had to subsist on a lunch of starch, prepared by the parent plant, until the plantlet springing from the kernel could obtain its own living from the soil and air, and that these starch lunches give wheat and other grains a commercial value. The interest is now awakened in the necessity that the farmer should prepare a fine seed-bed in his soil, and in the details of sowing, harvesting and milling. Some of the diseases and insect enemies of the wheat plant can be taken up and will be retained by the child because he has an interest in a living thing. Drawings can be made of many of the stages of growth of the plant in the egg shell. Wheat can be made to correlate with the geography by tracing its introduction and extension and transportation. By means of the exchange of correspondence, the wheat belt can be traced and plotted in every State of the Union. The children, through their teachers, in the States of Texas, Alabama, Louisiana and Georgia have shown most hearty co-operation in the exchange of correspondence, telling of the leading agricultural products.

Again, the children of Corning, during September and October, gathered seeds and divided them into classes as indicated by the means of travel that nature had provided. Some seeds, for instance, travel by means of a balloon; others catch onto passing objects, clothing, hair of animals, like tramps upon a passing freight train; and some have rudders to guide them through the air. A small boy felt himself a profound investigator when he discovered the advantage that some seeds have because they can float and take a ride on the water. Two men were heard discussing the wonderful vitality of weed seeds found in soil taken from a well twelve feet deep, asserting that after the clay from the bottom had remained exposed to the action of weather for a year or so, the growth of a few weeds followed. The children of Corning, after their investigations, could very well tell where the seeds of the weeds came from.

The pupils of Jamestown write most interestingly of their experience in summer planting of flowers. On the 23d of September the teacher in one of the grades had a flower show in her room.

Many interesting compositions and drawings have been received by children who had the tent caterpillar under observation during the spring months. In this case they rear the tiny caterpillar from the eggs, watch its growth during the larval stage and change of skins, see it go to sleep a crawling hairy creature,and after remaining a time a pupa, see it resurrected into a being with wings. This lesson, showing the four periods in the life-history of insects having a perfect metamorphosis, has shown the child what many learned judges and wise statesmen have never seen. We are in receipt of many creditable compositions and drawings showing the different transformations.

Nature-study can be made elastic. In the kindergarten it can be idealized so as to approach a fairy story. It can be intensified as the grades advance so that in the high school it will have all the solidity of pure science.

Summer schools.—The summer schools for teachers held by the Department of Public Instruction have been kindly opened to us for nature-study work. At the Chautauqua school last summer we supplied two teachers. The number of teachers who sought this instruction and performed laboratory work was about 80. The State Department also gave efficient instruction in similar lines.

At Thousand Island Park about 60 teachers took the work.

At the Ithaca school about 50 teachers were enrolled in nature-study work.

The best proof that the nature-study idea is bearing fruit is the fact that teachers are now asking for definite instruction in this subject. We are proposing, therefore, to offer a serious course in nature-study to school teachers at Cornell during the coming summer. This is probably the first specific nature-study school to be organized in this country. It has a special high-class faculty. It is designed to teach nature-study

in insect life,
in plant life,
on the farm.

General results.—Aside from all these means of pushing the nature-study idea, members of our staff visit teacher's organization, by request, and write for the press. We have also had the coöperation of many leading educators in all parts of the country. In fact, the enthusiasm with which the work has been received by those best capable to judge of its defects and merits is a constant surprise to us.

One of the most gratifying of these encomiums is contained in the last official report of the Honorable James Wilson, Secretary of Agriculture. He not only outlines the Cornell work specifically, but also makes the following very significant remarks on nature-study in the common schools:

"There is growing interest in education that relates to production. All classes of intelligent people favor it. Congress endowed colleges to teach it, and progress is being made, but not so rapidly as the growth of our country demands. More knowledge concerning what the farmer deals with every day would enable him to control conditions, produce more from an acre, and contribute more to the general welfare. The education of our people in common school, high school, and college has not been designed to prepare them for producing from the soil, excepting the very few who have found their way into our agricultural colleges. It is evident to educators in agricultural science that elementary study should be introduced into the common schools to give direction early in life.

"Agriculture, horticulture, forestry, gardening, and landscaping are delightful studies that attract people in all walks of life, but there is enough to be learned regarding each of these to require the devotion of a lifetime. The colleges and experiment stations endowed by the Federal Government provide for training along this line for longer or shorter periods at the institutions of the several States and Territories designed for this purpose; but while encouraging progress has been made in building up courses in these institutions that teach the sciences relating to production, instruction before going to college and after graduation is lacking. Nothing is being done in most of the common schools of the States to cultivate a taste for and lead the mind to inquire into and store up facts regarding nature, so that the young farmer may be directed into the path that leads to education concerning his future life work."

The following letter is from A. E. Winship, Boston, editor of the *Journal of Education*, and one of the leading educational critics of the day :

> Permit me, in thanking you for a set of the Nature-Study Leaflets, to say, from a fairly complete knowledge of what is being done educationally throughout the country, that there is no attempt through the schools to give a knowledge of nature and love for it that will compare for a moment in efficiency with the New York plan. It is intelligent, comprehensive, practical. The information is reliable—which is of prime importance—the presentation is interesting, and everything is adapted to the schools, even to untrained teachers.
>
> The influence of this work is being felt in the teaching of other subjects, so that Nature-Study, under the patronage of the State, has a mission in many phases of school work.

It was our first thought and effort to introduce the nature-study into the rural schools. But the strictly rural school is the most difficult to reach. The number of pupils is usually small and largely of the younger class, and patrons are easily led to believe that economy lies in employing a cheap teacher (commonly $5 to $6 per week), which means a teacher having minimum qualifications. If perchance an apprentice is employed and she shows enough progressiveness to take up nature-study, it is not long before this is recognized and better wages are offered by the village or town school, and she ceases to be a rural teacher.

Great educational movements are formulated and promulgated in the cities. They are copied by the villages and hamlets, and some of the impulse finally finds its way into the rural district school. We were therefore obliged to cast our pebble in the center of the pool and let the ripples work outwards. The cities took up the work with enthusiasm and often with avidity. We now begin to see the fulfillment of our hopes, for this year the requests for leaflets are coming mostly from the villages and cross-roads.

A year ago the nature-study work was still in its experimental stage, but we now feel that the greatest difficulties have been overcome. Nature-study will not revolutionize the world, but we believe that it is the most efficient single agency recently devised of affording permanent relief to the farming industries. It is natural, simple, fundamental, attractive. We are convinced that this enterprise alone is worth all the energy and money which has been devoted to the extension work.

b. THE READING-COURSE.

Every person is certain that a systematic course of reading would be productive of the greatest good to the farmer ; but only those who have tried to establish such a course know how difficult the task is. Those farmers whom it is chiefly desired to reach are not ready for books. It is said that book writings are too technical, but technical matter must be presented largely in technical language. Merely dropping technical terms is only a cheap means of writing in a popular way. The trouble is that the farmer does not think in books. He has not been trained in that way. The matter must be written from his standpoint and be digestible. It must be peptonized.

Our first effort to establish a reading-course was the recommendation of a set of books and bulletins (see Bulletin 122, p. 494). It did not work.

Last winter we devised a different plan. The purpose has been two-fold, —to charge the reader with information concerning his occupation, and to incite him to thought and observation. This we undertake to do by a process of pouring in and pumping out The subject for the winter of 1897–'98 was texture of the soil and conservation of moisture. A preliminary class of 1,500 was enrolled the winter before, and 5,000 during the winter of 1897–1898. In serving this class, 280,000 pages of literature were distributed free. The interest shown by the members has been so eager and intelligent that we have decided to give this feature of University extension work more attention than ever before.

The plan for the present winter is to divide the work into five subjects, three on soil and two on plant life. Very little attention will be given to the handicraft or the how of farming. Farmers have a very fair understanding of this ; but the why, the philosophy of cause and effect, a correct understanding of which will enable the farmer to act on a principle and not on a recipe —, these things are not understood.

The following circular (Nov. 15, 1898) will set the reading-course problem, as we see it, before the reader :

"I. WHAT IT IS.

"The object of this Reading-Course is to instruct farmers in thinking out their problems for themselves. Therefore, a problem is set, and the solution is suggested. Then the reader is requested to send us his answers and to ask any questions respecting the subject. It is not enough to read: one must think and ponder upon what he reads. Therefore, an indispensable part of a reading-course is the question and the reply.

"We want every reader to answer the questions for himself. We are after results; therefore we are not looking at the handwriting, nor the grammer, nor the spelling. Write us the questions which are troubling you, and we will do our best to give you a direct, personal and satisfactory answer. The persons who answer these questions are themselves farmers, and appreciate your efforts.

"This Reading-Course is maintained by the State (the Agricultural Extension or Nixon fund) and is therefore free. It will be conducted until March. Thereafter, the busy season will compel us to cease. We must therefore take it up with a will.

"II. HOW TO MANAGE IT.

"We expect to issue about five Reading-Lessons during the winter. We expect that one lesson will be sufficient for one month. Three lessons will be devoted to the soil.

"The first Lesson will be sent to all persons who were on our Reading-Course list last winter, and to any others who may apply or whose names are sent us. All those who reply to the questions in this first Lesson will be put on our permanent list.

"The best way to get the good of these Lessons is for the readers in any community to meet together (perhaps at some one's house) once a month. The Lesson is read by each party at home; then it is thoroughly discussed at the meeting. We can occasionally send a man or agent to such meetings to give instruction; but the agent will be sent only to those places in which the attendance has been the greatest and the replies to our inquiries have been the fullest.

"Read the Lessons carefully and critically. Test every statement by your own experience. Some of the statements are framed purposely for the bringing out of discussion.

"In some communities more advanced instruction or a greater amount of reading may be wanted. Write us, and we shall try to help you by suggesting topics and books."

The first Reading-Lesson of this new series comprises 8 pages and 12 topics, and is headed "The Soil: what it is." The second Lesson is on "Tillage and Under-drainage: reasons why."

We consider that the Reading-Course is yet in its experimental stage; but it is promising. As an experiment we are employing public-spirited farmers in three parts of the State to organize Reading-Centers within a small radius of their homes.

If this attempt is successful, we shall hope to extend the enterprise another year if the Extension work is continued.

It will be seen that the central idea of this Reading-Course movement is to educate the farmer rather than to give him mere information. We expect that it will be taken up most efficiently by the younger men. The direct result of it is to awaken a desire for more wisdom and to induce the party to go to school or college. Therefore, it appeals to the rising generation rather more than to the satisfaction of present-day problems.

Remarks by the Director;

The Director desires to say that the efficiency of the work has been greatly promoted by the helpful co-operation of the Secretary of Agriculture, Honorable James Wilson, Director A. C. True and Professor H. W. Wiley, of Washington, D. C. No less helpful have been the hearty support of the Commissioner of Agriculture, Honorable Charles A. Wieting, and the Superintendent of Education, Honorable Charles R. Skinner, and their associates. But most of all do we desire to acknowledge thanks to the many citizens of the State who have so appreciatingly received the instruction and to those who have so heartily entered into the work of investigation.

The various members of the staff seem to be imbued with the true missionary spirit, and have thrown themselves into the work with enthusiasm. Some of the professors and others have given freely of time and advice, writing leaflets and bulletins and working month after month, or even year after year, without remuneration, anxious only that the work be extended and energized.

In conclusion, it may be said that the Nixon fund is not an appropriation to Cornell University, but to the agricultural interests of the State, to be administered by Cornell University. The University has not asked for the legislation. The movement originated with the people and has been maintained by them. The law provides that the money is " to be expended in giving instruction throughout the State by means of schools, lectures and other university extension methods, or otherwise, and in conducting investigations and experiments; in discovering the diseases of plants and remedies; in ascertaining the best method of fertilization of fields, gardens and plantations; and best modes of tillage and farm management and improvement of live stock; and in printing leaflets and disseminating agricultural knowledge by means of lectures or otherwise; and in preparing and printing for free distribution the results of such investigations and experiments; and for republishing such bulletins as may be useful in the furtherance of the work; and such other information as may be deemed desirable and profitable in promoting the agricultural interests of the State. Such college of agriculture may, with the consent and approval of the commissioner of agriculture, employ teachers and experts and necessary clerical help to assist in carrying out the purposes of this bill."

Every capable judge is pronounced in his conviction that the many agencies—as institutes, bulletins, rural press, experiments, etc.—which have been prosecuted in the farmer's interest during recent years, and in many States, have had a wonderful effect in educating the farmer and in improving agriculture.

I. P. ROBERTS,
Director.

THE FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION TO THOSE WHO MAY DESIRE THEM.

39 **Creaming and Aerating Milk, 20 pp.**
40 **Removing Tassels from Corn, 9 pp.**
41 **Steam and Hot-Water for Heating Greenhouses, 26 pp.**
49 **Sundry Investigations of 1892, 56 pp.**
53 **Œdema of the Tomato, 34 pp.**
55 **Greenhouse Notes, 31 pp.**
61 **Sundry Investigations of the Year 1893, 54 pp.**
64 **On Certain Grass-Eating Insects, 58 pp.**
69 **Hints on the Planting of Orchards, 16 pp.**
71 **Apricot Growing in Western New York, 26 pp.**
72 **The Cultivation of Orchards, 22 pp.**
73 **Leaf Curl and Plum Pockets, 40 pp.**
74 **Impressions of the Peach Industry in N. Y., 28 pp.**
75 **Peach Yellows, 20 pp.**
76 **Some Grape Troubles in Western N. Y., 116 pp**
77 **The Grafting of Grapes, 22 pp.**
78 **The Cabbage Root Maggot, 99 pp.**
79 **Varieties of Strawberry Leaf Blight, 26 pp.**
80 **The Quince in Western N. Y., 27 pp.**
82 **Experiments with Tuberculin, 20 pp.**
84 **The Recent Apple Failures in N. Y., 24 pp.**
87 **Dwarf Lima Beans, 24 pp.**
92 **Feeding Fat to Cows, 15 pp.**
93 **Cigar-Case-Bearer, 20 pp.**
95 **Winter Muskmelons, 20 pp.**
96 **Forcing House Miscellanies, 43 pp.**
97 **Entomogenous Fungi, 42 pp**
101 **The Spraying of Trees and the Canker Worm, 24 pp.**
102 **General Observations in Care of Fruit Trees, 26 pp.**
103 **Soil Depletion in Respect to Careo Fruit Trees, 21 pp.**
104 **Climbing Cutworms in Western, N. Y. 51 pp**
105 **Test of Cream Separators, 18 pp.**
106 **Revised Opinions of the Japanese Plums, 30 pp.**
109 **Geological History of the Chautauqua Grape Belt, 36 pp.**
110 **Extension Work in Horticulture, 42 pp.**
114 **Spraying Calendar.**
116 **Dwarf Apples, 31 pp.**
117 **Fruit Brevities, 50 pp.**
119 **Texture of the Soil, 8 pp.**
120 **Moisture of the Soil and Its Conservation, 24 pp.**
122 **Second Report upon Extension Work in Horticulture, 36 pp.**
123 **Green Fruit Worms, 17 pp.**
124 **The Pistol-Case-Bearer in Western New York., 18 pp.**
125 **A Disease of Currant Canes, 20 pp.**
126 **The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.**
127 **A Second Account of Sweet Peas, 35 pp.**
128 **A Talk about Dahlias, 40 pp.**
129 **How to Conduct Field Experiments with Fertilizers, 11 pp.**
130 **Potato Culture, 15 pp.**
131 **Notes upon Plums for Western New York, 31 pp.**
132 **Notes upon Celery, 34 pp.**
133 **The Army-Worm in New York, 28 pp.**
134 **Strawberries under Glass, 10 pp.**
135 **Forage Crops, 28 pp**
136 **Chrysanthemums, 24 pp.**
137 **Agricultural Extension Work, sketch of its Origin and Progress, 11 pp.**
138 **Studies and Illustrations of Mushrooms; I, 32 pp.**
139 **Third Report upon Japanese Plums.**
140 **Second Report on Potato Culture, 24 pp**
141 **Powdered Soap as a Cause of Death Among Swill-Fed Hogs.**
142 **The Codling-Moth.**
143 **Sugar Beet Investigations, 88 pp.**
144 **Suggestions on Spraying and on the San José Scale.**
145 **Some Important Pear Diseases.**
146 **Fourth Report of Progress on Extension Work, 26 pp.**
147 **Fourth Report upon Chrysanthemums, 36 pp.**
148 **Quince Curculio, 26 pp.**
149 **Some Spraying Mixtures.**

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1898.

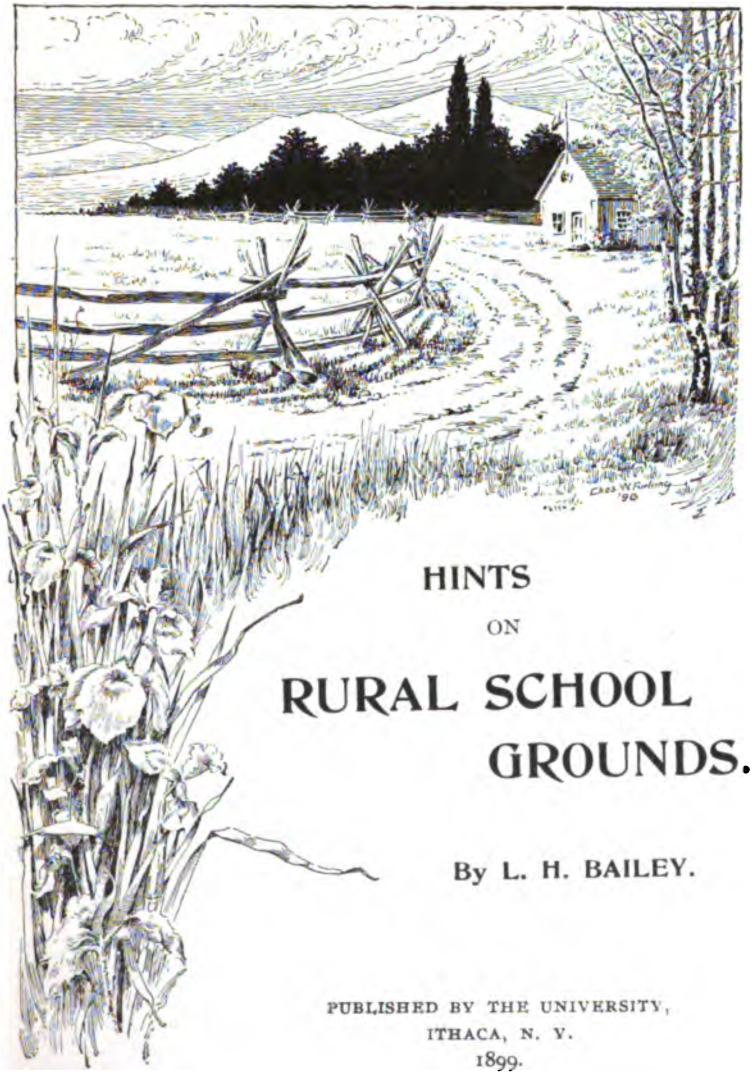
150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.
152. Studies in Milk Secretion.
153. Impressions of our Fruit-Growing Industries.
154. Tables for Computing Rations for Farm Animals.
155. Second Report on the San José Scale.
156. Third Report on Potato Culture.
157. The Grape-vine Flea-beetle.
158. Source of Gas and Taint Producing Bacteria in Cheese Curd.
159. An Effort to Help the Farmer.

Bulletin 160. **January, 1899.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

HORTICULTURAL DIVISION.



HINTS
ON
RURAL SCHOOL GROUNDS.

By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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CORNELL UNIVERSITY, January 2, 1899.

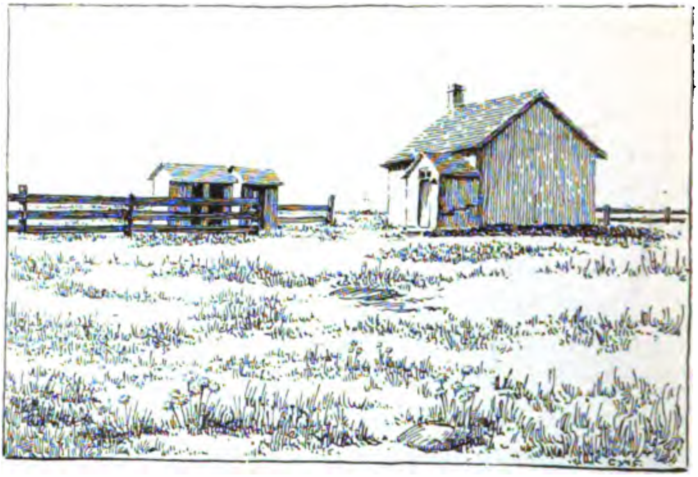
HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: In the effort to extend the teaching of nature and to popularize farming subjects, we have found the nature-study leaflets to be invaluable. These leaflets are now so well established in the estimation of New York teachers that we are obliged to print them in editions of 25,000. These afford subject-matter for direct teaching. But the surroundings of the child should also be such as to interest him in rural subjects. The home and the school premises should supplement the explicit work of the teacher.

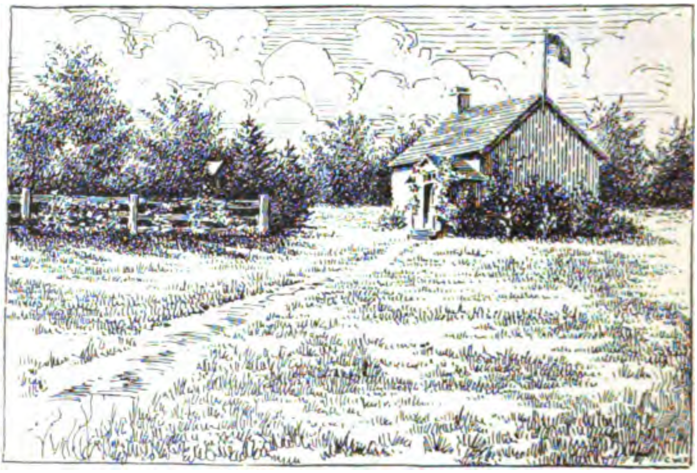
We have endeavored to provide suggestions for the improvement of home surroundings in a number of bulletins; and we hope that more will follow. For many years, Professor Bailey has been studying the problem of the improvement of rural school grounds, but it is only now that he has felt that the time is ripe for a distinct movement in this direction. This bulletin is the first move. It strikes at one of the greatest evils connected with the education of the farmer's children. We hope to follow up the movement, and eventually to give suggestions for the interior of the schoolhouse.

These recommendations are the result of long study of trees and shrubs as adapted to New York State, and of the principles of landscape gardening. The report is submitted for publication as a bulletin under Chapter 67 of the Laws of 1898.

I. P. ROBERTS, Director.



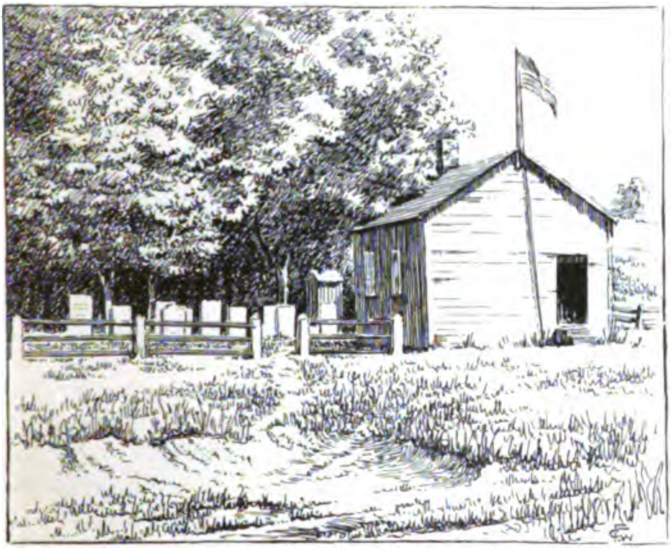
21.—*Where children are taught. An actual example, in one of the most prosperous fruit-growing sections of New York.*



22.—*A suggestion in planting.*

HINTS ON RURAL SCHOOL GROUNDS.

One's training for the work of life is begun in the home and fostered in the school. This training is the result of a direct and conscious effort on the part of the parent and teacher, combined with the indirect result of the surroundings in which the child is placed. The surroundings are more potent than we think; and they are usually neglected. It is probable that the antipathy to farm life is formed before the child is able to reason on the subject. An attractive play-ground will do more than a profitable wheat crop to keep the child on the farm.



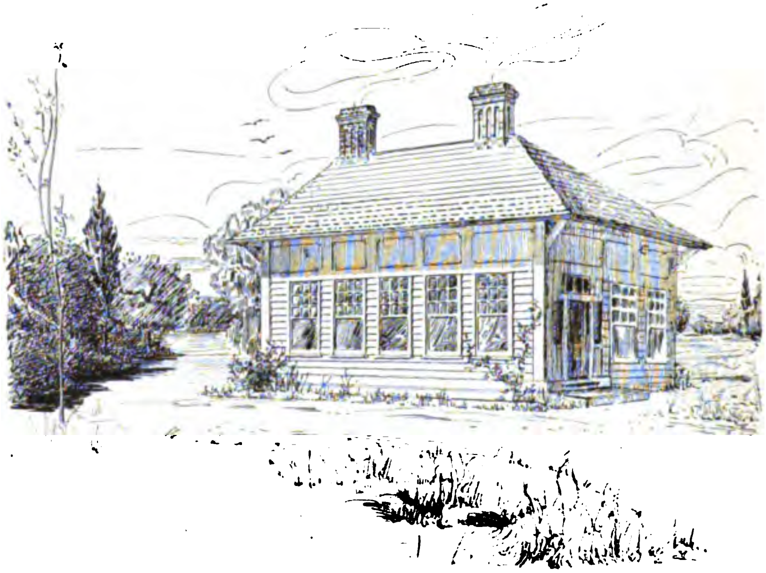
23.—*The beginning and the end,—schoolhouse and graveyard. In eastern New York.*

a. THE FACT.

Bare, harsh, cheerless, immodest,—these are the facts about the average rural school ground. Observe Fig. 21.

Children cannot be forced to like the school. They like it only when it is worth liking. And when they like it, they learn. The fanciest school apparatus will not atone for a charmless school ground. A child should not be blamed for playing truant if he is sent to school in a graveyard. Observe Fig. 23.

It would seem that land is very precious. Very little of it can be afforded for a school ground. A quarter of an acre of good land will raise four bushels of wheat, and this wheat may be worth three or four dollars a year. We cannot afford to devote such valuable property to children. We can find a bit of swamp, or a sand hill, or a treeless waste. The first district school I taught was on a heartless hillside. The premises had two or three disconsolate oaks, and an old barrel was stuck in the top of one of them. The second school was on an island in a swamp. The mosquitoes loved it.



24.—*A suggestion for a simple little schoolhouse.*

The school building is generally little more than a large box. It has not even the charm of proper proportions. A different shape, with the same cost, might have made an attractive building. Even a little attention to design might make a great difference in the looks of a schoolhouse; and the mere looks of a schoolhouse has a wonderful influence on the child. The railroad corporation likes to build good-looking station-houses, although they have no greater capacity than homely ones. I asked an architect for a simple plan of a cheap school house. He gave me Fig. 24. Plans for the improvement of shoolhouses may be obtained of the Superintendent of Public Instruction, Albany.

The following sentences are extracted from the "Report of the Committee of Twelve on Rural Schools," of the National Educational Association (1897):

"The rural schoolhouse, generally speaking, in its character and surroundings is depressing and degrading. There is nothing about it calculated to cultivate a taste for the beautiful in art or nature."

"If children are daily surrounded by those influences that elevate them, that make them clean and well-ordered, that make them love flowers, and pictures, and proper decorations, they at last reach that degree of culture where nothing else will please them. When they grow up and have homes of their own, they must have them clean, neat, bright with pictures, and fringed with shade trees and flowers, for they have been brought up to be happy in no other environment."

"The rural schoolhouse should be built in accordance with the laws of sanitation and modern civilization. It never will be until the State, speaking through the Supervisor, compels it as a prerequisite for receiving a share of the public funds."

b. HOW TO BEGIN A REFORM.

We will assume that there is one person in each rural school district who desires to renovate and improve the school premises. There may be two. If this person is the school commissioner or the teacher, so much the better.

Let this person call a meeting of the patrons at the schoolhouse. Lay before the people the necessity of improving the premises. Quote the opinions of intelligent persons respecting the degrading influence of wretched surroundings; or even read extracts from this bulletin. The coöperation of the most influential men of the district should be secured before the meeting is called.

Propose a "bee" for improving the school grounds. John Smith will agree to repair the fence (or take it away, if it is not needed). Jones will plow and harrow the ground, if plowing is necessary. Brown will sow the grass seed. Black and Green and White will go about the neighborhood with their teams for trees and bushes. Some of these may be got in the edges of the woods, but many of the bushes can be picked up in front yards. Others will donate their labor towards grading, planting, and cleaning up the place.

The whole thing can be done in one day. Perhaps Arbor Day can be chosen.

C. THE PLAN OF THE PLACE.

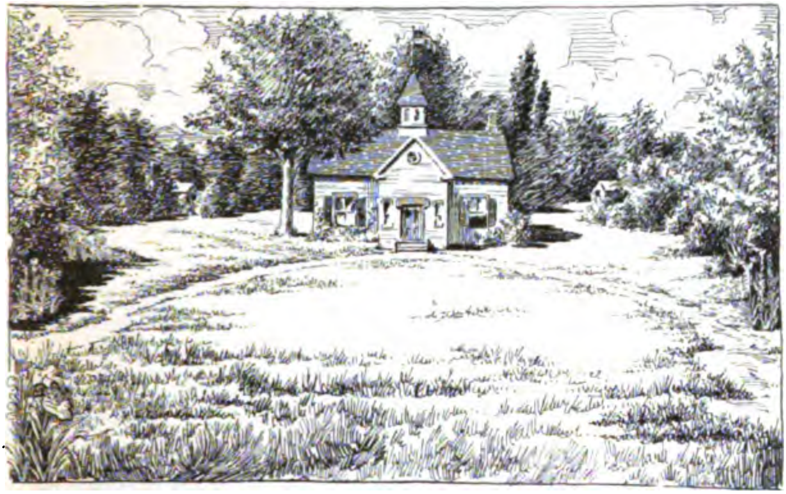
This is the most important part of the entire undertaking,—the right kind of a plan for the improvement of the grounds. The person who calls the meeting should have a definite plan in mind; and this plan may be discussed and adopted. The remainder of this bulletin is devoted to plans for school grounds and means of working them out. If any person is interested in this subject, he should have our Bulletin 121, on the "Planting of Shrubbery."

Begin with the fundamentals, not with the details.—If an artist is to make a portrait, he first draws a few bold strokes, representing the general outline. He "blocks out" the picture. With the general plan well in mind, he gradually works in the incidentals and the details,—the nose, eyes, beard.

Most persons reverse this natural order when they plant their grounds. They first ask about the kinds of roses, the soil for snowballs, how far apart hollyhocks shall be planted. It is as if the artist first asked about the color of the eyes and the fashion of the neck-tie; or as if the architect first chose the color of paint and then planned his building. The result of this type of planting is that there is no plan, and the yard means nothing when it is done. Begin with the plan, not with the plants.

The place should mean something.—The home ground should be home-like, retired and cosy. The school ground should be set off from the bare fields and should be open enough to allow of play-grounds. It should be hollow,—well planted on the sides, open in the interior. The side next the highway should contain little planting. The place should be a picture, not a mere collection of trees and bushes. Fig. 25 shows what I mean.

As seen in the picture (Fig. 25), this style of planting seems to be too elaborate and expensive for any ordinary place. But if the reader will bear with me, he shall learn otherwise.



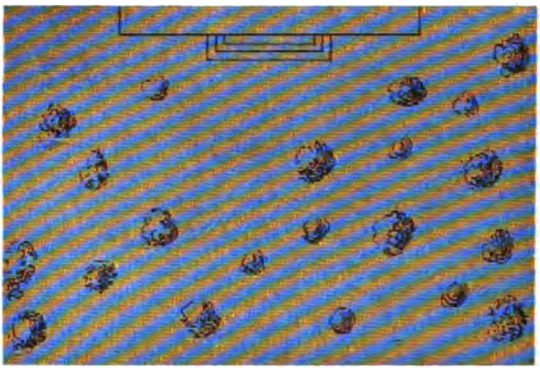
25.—*A picture, of which a schoolhouse is the central figure.*

Keep the center of the place open.— Do not scatter the trees over the place. They will be in the way. The boys will break them down. Moreover, they do not look well when scattered over the whole area. When an artist makes a picture with many people in it, he does not place the persons one by one all over his canvas. He masses them. Thereby he secures a stronger effect. He focusses attention, rather than distributes it.

The diagrams (Figs. 26, 27), taken from Bulletin 121, make this conception plain. The same trees and shrubs can be used to make either a nursery or a picture. But it is more difficult to make the nursery, and to keep it in order, because the trees grow one at a place in the sod, and they are exposed to accidents.

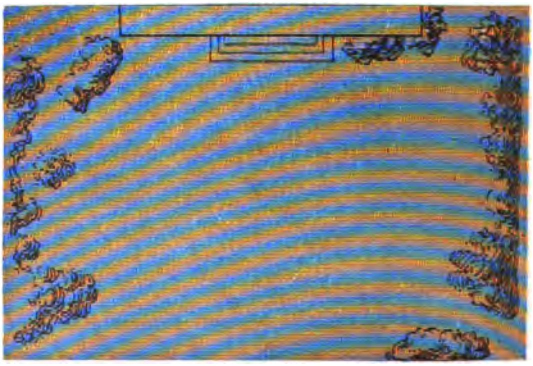
Go to the blackboard. With four lines, represent the borders of the school grounds, as in Fig. 28. Indicate the schoolhouse and the outbuildings. Existing trees may be located by small circles. Now you have the facts, or the fixed points.

Now put in the walks. The first fixed point is the front door. The other fixed point is the place or places at which the children enter the grounds. Join these points by the most direct and simplest curves possible. That is all there is of it. In many, or perhaps most places, the house is so near the highway that only a straight walk is possible or advisable.



26.—*The common or nursery type of planting.*

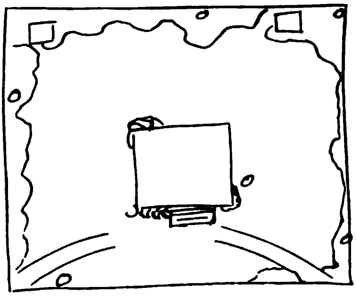
Next comes the planting. Let it be irregular and natural, and represent it by a wavy line, as in Fig. 28. First of all, cover up the out-houses. Then plant heavily on the side next the swamp or a disagreeable barnyard, or in the direction of the prevailing wind. Leave openings in your plan wherever there are views to be had of fine old trees, attractive farm homes, a brook, or



27.—*The proper or pictorial type of planting.*

a beautiful hill or field. Throw a handful of shrubs into the corners by the steps, and about the bare corners of the building.

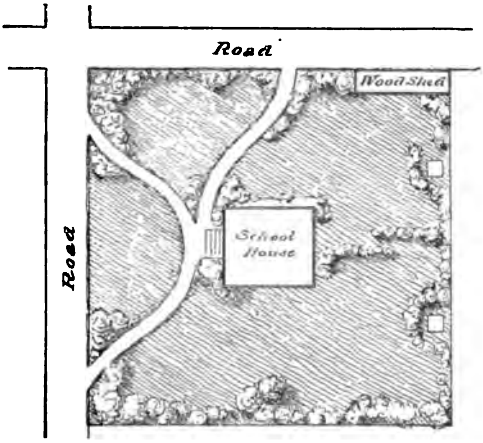
You now have a plan to work to. It has been the work of five minutes at the blackboard.



28.—*The blackboard plan.*

Sometimes the problem is not so simple as all this. There may be three entrances to the grounds and a highway on two sides. Fig. 29 is a plan made for such a place in western New York. It was thought to be necessary to separate the play-grounds of the boys and girls. This was done by a wide hedge-row of bushes running back from the schoolhouse.

An interesting case as shown in Figs. 21 and 22. It is indecent to put the two outbuildings together. But it was assumed that it would not be allowable to move them. The place is bald and cheerless. The outlay of a day's work, and no money, might cause it to look like Fig. 22 inside of three or four years.



29.—*Suggestions for the planting of a school-yard upon four corners. From "Lessons with Plants."*

Perhaps some persons object to so much shrubbery. They look upon it as mere brush. Very well; then use trees alone. But do not scatter them hit and miss over the place. Throw them in at the side, as in Fig. 30. Give room for the children to play; and make the place a picture at the same time. Three or four trees may be planted near the building to shade it, but the heaviest planting should be on the sides.

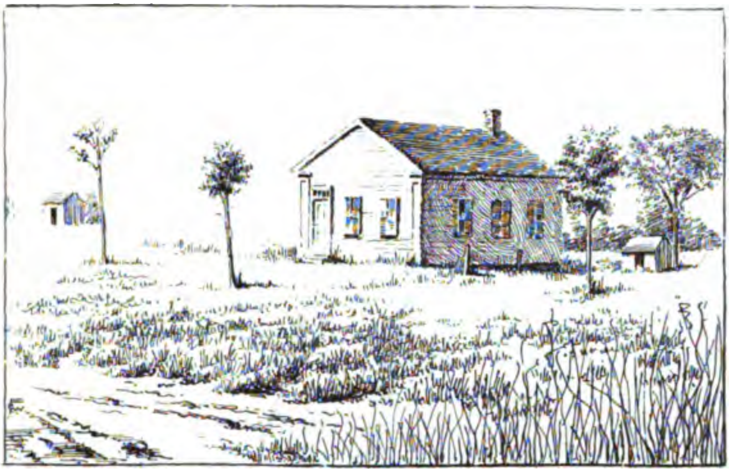
The mere planting of trees and shrubs is the smaller part of the problem.—Arbor day has emphasized the mere planting of trees. Fortunately, many of the trees do not live. They are too often put in the wrong places. If the love of trees could be combined with some purpose in the planting, the results would be much better. Fig. 31 suggests Arbor Day planting; and this is certainly much better than nothing. These four trees will be useful in their present positions, but the place will still remain bare. The great thing—the border planting—has been omitted, and the incidental thing has been done.

30.—*A border planting of trees.*

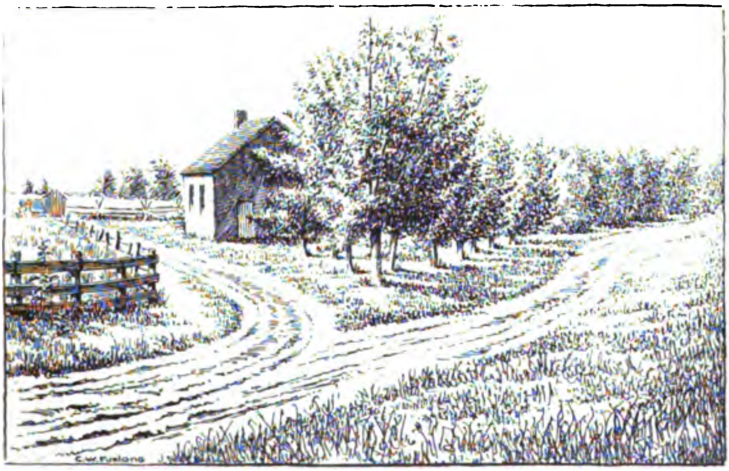
Observe how the long foliage-mass adds charm to Fig. 32. A row is better than mere scattered trees. But even this planting is not ideal. Heavy planting should have been made along the fence beyond the schoolhouse. There are too many trees between the border row and the house, although this is not a serious fault. A few bushes and vines would relieve the barrenness of the house; so would one or two trees close against the house on the side next the road. But this place is so much more attractive than most rural school premises that one ought not to find fault with it.

d. HOW TO MAKE THE IMPROVEMENTS.

Every effort should be exerted to do the work well in the beginning. If all preparations are thoroughly considered, and the details carried out with care, the premises should become more attractive year by year with almost no annual outlay of labor. The school grounds should be able to take care of themselves when once the place is set in order. Of course, better results are to be expected when much labor is put on the grounds each year, but it is useless to advise such expenditure for the rural schools. But it is surprising what excellent results can be secured with almost no attention from year to year. The beau-



31.—*Trees enough in the center, but the place needs a back-ground.*



32.—*A row of willows makes the place attractive.*

tiful garden in Fig. 34 has received practically no labor for three years except that required to mow the grass.

Making the sod.—In many cases the school yard is already level or well graded and has a good sod, and it is not necessary to plow it and re-seed it. It should be said that the sod on old lawns can be renewed without plowing it up. In the bare or thin places, scratch up the ground with an iron-toothed rake, apply a little fertilizer, and sow more seed. Weedy lawns are those in which the sod is poor. It may be necessary to pull out the weeds ; but after they are out, the land should be quickly covered with sod or they will come in again. Annual weeds, as pigweeds, ragweed, can usually be crowded out by merely securing a heavier sod. A little clover seed will often be a good addition, for it supplies nitrogen and has an excellent mechanical effect on the soil.

The ideal time to prepare the land is in the fall, before the heavy rains come. Then sow in the fall, and again in early spring on a late snow. However, the work may be done in spring, but the danger is that it will be put off so long that the young grass will not become established before the dry hot weather comes.

The only outlay of money required for the entire improvement is for grass seed. The best lawn grass for New York is June-grass or blue-grass. Seedsmen know it as Poa pratensis. It weighs but 14 pounds to the bushel. Not less than three bushels should be sown to the acre. We want many very small stems of grass, not a few large ones : for we are making a lawn, not a meadow.

Do not sow grain with the grass seed. The June-grass grows slowly at first, however, and therefore it is a good plan to sow timothy with it, at the rate of two or three quarts to the acre. The timothy comes up quickly and makes a green ; and the June-grass will crowd it out in a year or two. If the land is hard and inclined to be too dry, some kind of clover will greatly assist the June-grass. Red clover is too large and coarse for the lawn. Crimson clover is excellent, for it is an annual, and it does not become unsightly in the lawn. White clover is perhaps best, since it not only helps the grass but looks well in the sod. One or two pounds of seed is generally sufficient for an acre.

At first the weeds will come up. Do not pull them. Mow the lawn as soon as there is any growth large enough to mow. Of course, the lawn mower is best, but there is no use of recommending it for rural school yards. Then use the ordinary field mower. When the sod is established, mowing the yard three or four times a year will be sufficient. And here is another advantage of the open-centered yard which I have recommended. — it is easily mown. It would be a fussy matter to mow a yard planted after the fashion of Fig. 26; but one like Fig. 27, is easily managed. A yard like Fig. 25 can be mown in a half hour.

How to make the border planting.—The borders should be planted thick. Plow up the strip. Never plant these trees and bushes in holes cut in the sod. Scatter the bushes and trees promiscuously in the narrow border. In home grounds, it is easy to run through these borders occasionally with a cultivator, for the first year or two.

Make the edges of this border irregular. Plant the lowest bushes on the inner edge. Fig. 33 shows how a certain yard was marked out for the planting. The whole area had been plowed, rolled, harrowed and raked. Grass seed had been sown and raked in. Then a line was drawn, by means of a rake handle, to represent the edges of the border planting. The interior or lawn space was now rolled, and the soft area along the borders was left for the planting. Five years later, the place looked as shown in Fig. 34. Imagine a schoolhouse at the end of that garden!

For all such things as lilacs, mock-oranges, Japan quinces, and bushes that are found along the roadsides, two or three feet apart is about right. Some will die anyway. Cut them back one-half when they are planted. They will look thin and stiff for two or three years; but after that they will crowd the spaces full, lop over on the sod, and make a billow of green. Prepare the land well, plant carefully; and let the bushes alone.

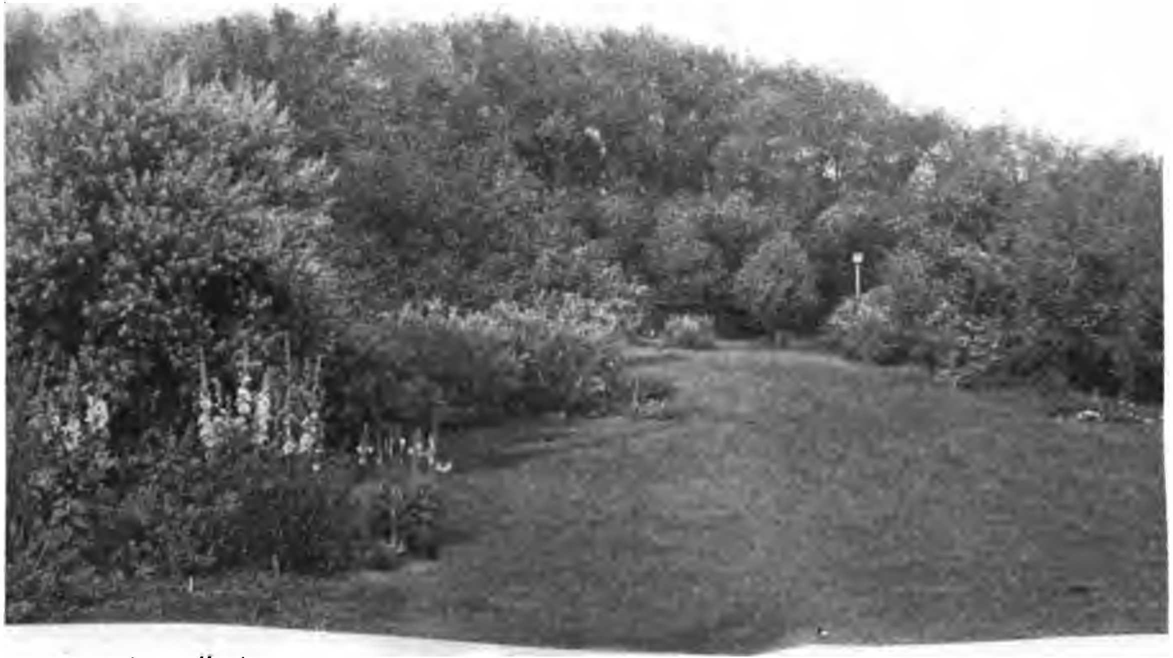
The kinds of plants for the main planting.—We now come to the details,—the particular kinds of plants to use. One great principle will simplify the matter: the main planting should be for foliage effects. That is, think first of giving the place a heavy bordermass. Flowers are mere decorations.

Select those trees and shrubs which are the commonest, because they are cheapest, hardiest and most likely to grow. There is no district so poor and bare that enough plants cannot be secured, without money, for the school yard. You will find them in the woods, in old yards, along the fences. It is little matter if no one knows their names. What is handsomer than a tangled fence-row?

Scatter in a few trees along the fence and about the buildings. Maples, basswood, elms, ashes, buttonwood, pepperidge, oaks, beeches, birches, hickories, poplars, a few trees of pine or spruce or hemlock,—any of these are excellent. If the country is bleak, a rather heavy planting of evergreens about the border, in the place of so much shrubbery, is excellent.

33.—*A newly made landscape garden, ready for the border planting.*

For shrubs, use the common things to be found in the woods and swales, together with roots which can be had in every old yard. Willows, osiers, witch hazel, dogwood, wild roses, thorn apples, haws, elders, sumac, wild honeysuckles,—these and others can be found in every school district. From the farm yards can be secured snowballs, spireas, lilacs, forsythias, mock-



34.—Five years' growth upon the area shown in Fig. 33. On the Cornell horticultural grounds. From our Bulletin 121.

35.—*It is easy to make a yard as good as this.*

oranges, roses, snowberries, barberries, flowering currants, honeysuckles and the like.

Vines can be used to excellent purpose on the outbuildings or on the schoolhouse itself. The common wild Virginia creeper (shown on the right in Fig. 36) is the most serviceable. On brick or stone school houses the Boston ivy or Japanese ampelopsis may be used, unless the location is very bleak. This is not hardy in the northern parts of the State. Honeysuckles, clematis and bitter-sweet are also attractive. Bowers are always interesting to children; and actinidia (to be had at nurseries) is best for this purpose.

Kinds of plants for decoration.—Against these heavy borders and in the angles about the building, many kinds of flowering plants can be grown. The flowers are much more easily cared for in such positions than they are in the middle of the lawn, and they also show off better. Notice how striking the holyhocks are in Figs. 34 and 37. They have a background. Even a clump of weeds looks well when it is in the right place. Observe Fig. 36.

36.—*A clump of weeds in the corner by the house—motherwort and Virginia creeper. How pretty they are!*

It is impossible to grow many flowers in the school ground under present conditions, for what is everybody's business is nobody's business; and then, the place is neglected all through the summer. But the children can be taught to plant many things.

37.—*A dainty bit,—flowers against a background.*

Only those flowers should be used which are very easy to grow and which have the habit of taking care of themselves. They should also be such as bloom in spring or fall, when the school is in session. Perennial plants—those which live from year to year—are excellent. Of these, day lilies, bleeding hearts, pinks, bluebells, hollyhocks, perennial phlox and hibiscus, are always useful. Nothing is better than the common wild asters and goldenrods. They will grow almost anywhere and they improve when grown in rich ground and given plenty of room; and they bloom in the fall.

Many kinds of bulbs are useful, especially as so many of them bloom very early in spring. We propose to issue a nature-study leaflet on this subject the coming season. Think of a school yard with crocuses, daffodills and tulips in it!

Annual flowers may be grown along the borders, out of the way of the play-grounds. China asters, petunias and California poppies are very attractive, and they are easy to grow. They bloom in the fall. Phlox, sweet peas, allyssum, and many others are also useful. Consult Bulletin 161.

While the main planting should be made up of common trees and shrubs, a rare or strange plant may be introduced now and then from the nurseries, if there is any money with which to buy such things. Plant it at some conspicuous point just in front of the border, where it will show off well, be out of the way, and have some relation to the rest of the planting. Two or three purple-leaved or variegated-leaved bushes will add much spirit and verve to the place; but many of them make the place look fussy and overdone.

e. GENERAL REMARKS.

More than one-third of all public schools will probably always be in the country. They will have most intimate relations with rural life. We must make that life attractive to the pupils.

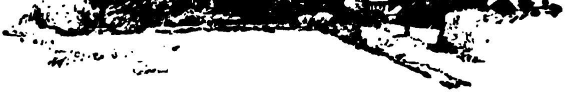
In Europe there are school gardens, and similar plans are recommended for this country. It is certainly desirable that some area be set aside for the actual cultivation of plants by the children and for the growing of specimens to be used in the school room. However, the conditions of Europe are very different from ours. In the rural school in Germany and other countries, the school house is the teacher's home. He lives in it, or by it. The summer vacation is short. In this country, there is no one to care for the rural school ground in the long summer vacation. Teachers change frequently. It is impossible to have uniformity and continuity of purpose. In the Old World, the rural schools are in the hamlets.

We shall be very glad to correspond with any persons who are interested in improving school premises, either on the lines herein suggested, or in other directions. The improvement must come, or, one by one, the rural schools will die out for lack of pupils. In the struggle for existence, the pupils will more and more seek the more attractive schools. There must be rural schools, whether in the open country or in the hamlet; and wherever they are, they must be cheered and brightened.

A Flower Day every October would be a fitting complement of Arbor Day. Already, flower shows have been held in various rural schools. They are symbols of the harvest. We want to focalize this movement in the coming year. We call upon every citizen for sympathy and coöperation.

A revolution in rural school grounds will not come suddenly. Here and there a beginning will be made; and slowly the great work will spread.

L. H. BAILEY.



Bulletin 161. **January, 1899.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

HORTICULTURAL DIVISION.

ANNUAL FLOWERS.

By G. N. LAUMAN and L. H. BAILEY.

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1899.

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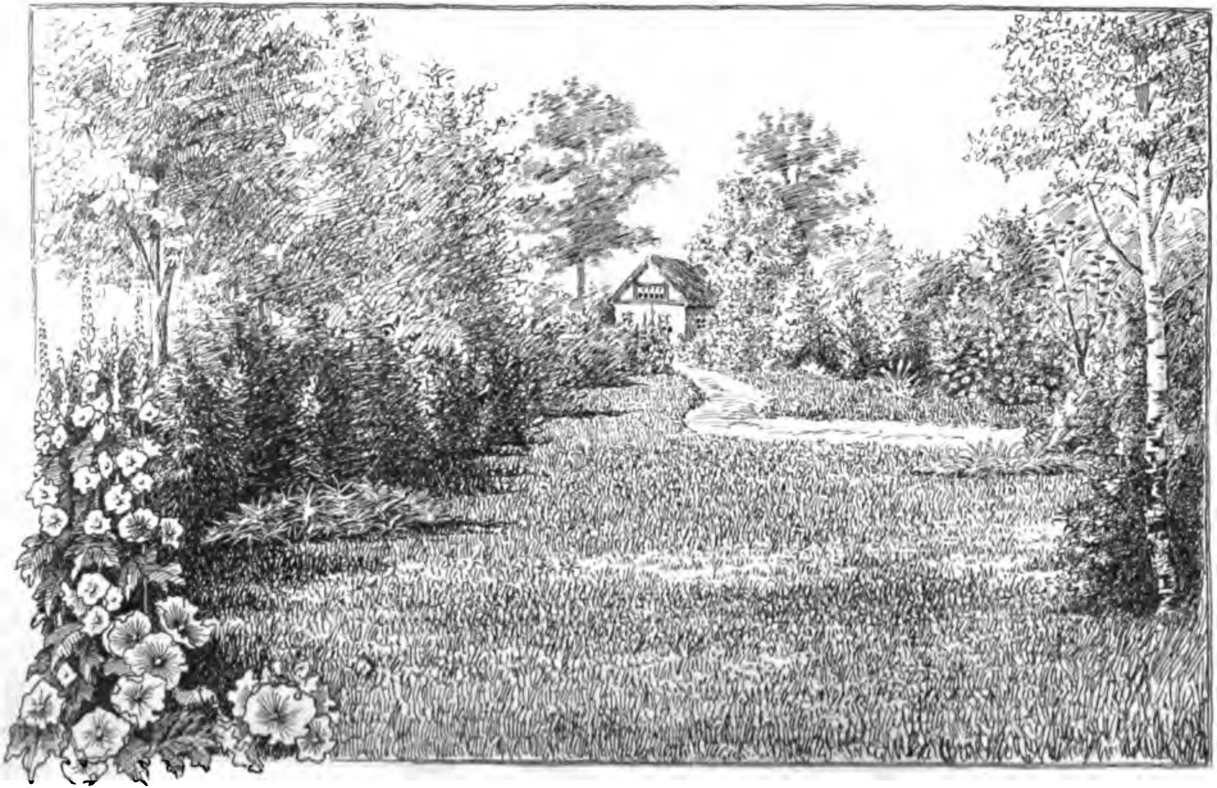
CORNELL UNIVERSITY, ITHACA, Jan. 6, 1899.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir:—The following report is submitted as a bulletin under Chapter 67 of the Laws of 1898. The first part of it is designed for general reading and application, and is a part of Professor Bailey's general movement towards improving rural homes and schools. The second part is more technical, and is designed more for the use of florists and those who make a special study of flower-growing; although the table and summary will enable persons unacquainted with flowers to select kinds for particular colors, heights, seasons, and uses. It is customary to describe flowers in superlative terms, and it is difficult for the beginner to make a wise selection. Only those kinds are included in the table which are easy for the amateur to grow in this State; and it is hoped that the list will spread information of simple flower-growing. This part II. is the work of G. N. Lauman, Assistant in the Horticultural Department, although all the work has been done under the personal direction and care of the head of that Department. Botanical specimens of all these 459 kinds (and of others not reported here) are preserved in the herbarium of the Experiment Station.

I. P. ROBERTS,

Director.



38.—*A cozy back yard. Flowers may be thrown in freely along the borders, not in beds in the center of the area.*

ANNUAL FLOWERS.

I. GENERAL REMARKS. (*L. H. Bailey.*)

EFFORTS have been made in the past few years, under the auspices of the Agricultural Extension work, to improve the surroundings of rural homes. To this end we have issued reports on flowers and the planting of shrubbery; and the present bulletin is another effort in the same direction.

During the past few years, the best thought of many able men and women has been given to the condition of the farmer and the status of agriculture. Many movements looking to the betterment of rural affairs are now in progress. It is probable that every one of them is productive of permanently good results; and the combined effects must be most beneficent. I believe, however, that the pecuniary side of the agricultural question has been too greatly emphasized in these schemes. It is, of course, incontrovertible that the greatest single problem is that of the earning power of the farm; but it is not nine-tenths of the question, as one might conclude from the current agricultural discussions.

Great numbers of farmers earn enough as it is, but they do not have the knack of doing things with the greatest economy of time and effort, and farm homes are not often designed to afford the greatest pleasure and comfort of living. Every person should know the great fact that the most successful life is the happiest one, and that the happiest one is that in which the common and little things awaken the greatest number of mental impressions. Successful and enjoyable farming, therefore, depends largely upon one's attitude of mind towards the things with which he deals and lives. If one derives pleasure from a daisy, a hill of potatoes, and a pigweed, then each of these plants is practical and worth the growing.

Like or dislike of the farm is often, and probably generally, formed before the child is old enough to be influenced by the profit-and-loss side of farming. A pleasant and happy home is the very first means of keeping the boy on the farm. One means of making the home attractive is to brighten the place with flowers.

For two years the Horticultural Department has made studies of those flowers which bloom freely the same year the seeds are sown. The primary use of this investigation is to enable us to give advice as to home-making; but it is hoped that the statistics of the plants, as given in Part II., will be useful to florists, catalogue makers, and others who have particular interest in the subject.

Flowers should be accessories.—The main planting of any place should be of trees and shrubs. (Consult Bulletin 121 on "Planting of Shrubbery," 160 on "Rural School Grounds," and 90 on "China Asters and Flower Beds.") The flowers are then used as decorations. They may be thrown in freely about the borders of the place, not in beds in the center of the lawn. They show off better when seen against a background: this background may be foliage, a building, a rock, or a fence.

39.—*The open-centered yard.*

Where to plant flowers is really more important than what to plant. In front of bushes, in the corner by the steps, against the foundation of the residence or outhouse, along a fence or a walk,—these are places for flowers. A single petunia plant against a background of foliage (as shown on the title-page) is worth a dozen similar plants in the center of the lawn. Fig. 38 shows a cozy back yard in which shrubs and trees are the main features and bright flowers are the incidents. Too many flowers make a place over-gaudy. Too much paint may spoil the effect of a good building. The decoration of a yard, as of a house, should be dainty.

The open-centered yard may be a picture: the promiscuously planted yard may be a nursery or a forest. A little color scattered in here and there puts the finish to the picture. A dash of color gives spirit and character to the brook or pond, to the ledge of rocks, to the old stump, or to the pile of rubbish.

40.—*A dash of color.*

A flower garden.—But the person may want a flower garden. Very well; that is a different matter. It is not primarily a question of decoration of the yard but of growing flowers for flowers' sake. It is not the furnishing of a house, but the collecting of interesting and beautiful furniture. The flower garden, therefore, should be at one side of the residence or at the rear; for it is not allowable to spoil a good lawn even with flowers. The size of the garden and the things to be grown in it must be determined by the likes of the person and the amount of time and land at his disposal; but a good small garden is much more satisfactory than a poor large garden. Prepare the land thoroughly, fertilize it resolve to take care of it, select the kind of plants you like; then go ahead.

41.—*A dainty edging of flowers.*

Plants for screens.—Many annual plants make effective screens, and covers for unsightly places. Wild cucumber (or echinocystis), cobea, and sweet peas may be used to decorate the tennis screen or the chicken-yard fence. The alley fence, the smoke-house, the children's play-house, may be screened with morning glories, flowering beans, and other twiners and climbers. The windows may be screened and decorated by vines grown either in the ground or in window-boxes.

Efficient screens can be made of many strong-growing and large-leaved plants, of which castor beans, sunflowers, cannas, tobacco and other nicotianas (Fig. 43 is one), striped or Japanese corn, are the chief. But it is not the mission of this bulletin to report upon foliage plants.

42.—*The decorated tennis fence.*

How to grow annuals.—The annual flowers of the seedsmen are those which give their best bloom in the very year in which the seeds are sown. The true annuals are those plants which complete their entire life-cycle in one season. Some of the so-called annual flowers will continue to bloom the second and third years, but the bloom is so poor and sparse after the first season that it does not pay to keep them.

43.—*Strong-growing and large-leaved herbs make excellent screens.* (*From the French.*)

Most annuals will bloom in central New York if the seeds are sown in the open ground when the weather becomes thoroughly settled. But there are some kinds, as cosmos and moon-flowers, for which our season is commonly too short to give good bloom. These kinds may be started early in the house or in hotbeds; and similar treatment may be given any plants of which it is desired to secure blooms before the normal time.

Prepare the ground thoroughly and deep. Annuals must make a quick growth. See that the soil contains enough humus or vegetable mold to make it rich and enable it to hold moisture. If the ground is not naturally rich, spade in well-rotted manure or mold from the woods. A little commercial fertilizer may help in starting off the plants quickly. Prepare the land as early in spring as it is in fit condition, and prevent evaporation by keeping the surface loose by means of raking.

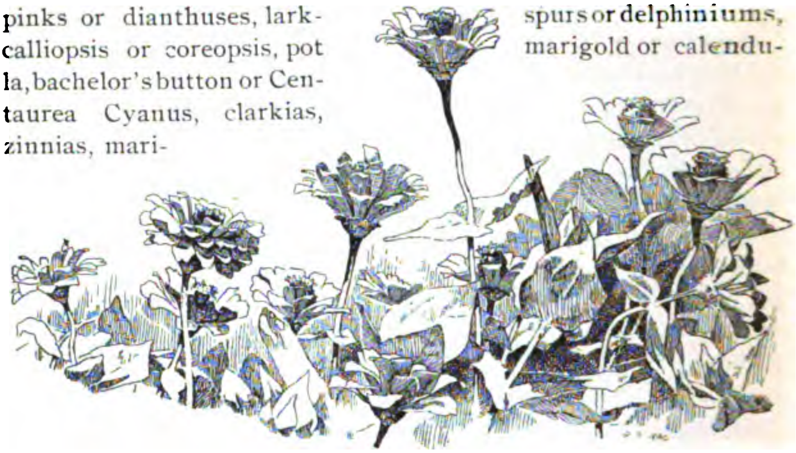
If the flowers are to be grown about the edges of the lawn, make sure that the grass roots do not run underneath them and rob them of food and moisture. It is well to run a sharp spade deep into the ground about the edges of the bed every two or three weeks for the purpose of cutting off any grass roots which may have run into the bed. If beds are made in the turf, see that they are three feet or more wide, so that the grass roots will not undermine them. Against the shrub borders, this precaution may not be necessary. In fact, it is desirable that the flowers fill all the space between the overhanging branches and the sod. Observe the picture on the title-page.

Sow the seeds freely. Many will not germinate. Even if they do all germinate, the combined strength of the rising plantlets will break the crust on the hard soils; and in the thinning which follows, only strong and promising plants are allowed to remain. Better effects are also often secured when the colors are in masses, especially if the flowers are thrown into the bays of heavy shrub borders like those in Fig. 38.

Plants continue to bloom for a longer period if they are not allowed to produce seeds. The flowers should be picked, if possible, as soon as they begin to fade.

The kinds of annuals.—In the selection of the kinds of annuals, one's personal preference must be the guide. Yet there are some groups which may be considered to be standard or general-purpose plants. They are easily grown almost anywhere and are sure to give satisfaction. The remaining plants are mostly such as have secondary value, or are adapted to particular purposes or uses. By consulting the summary lists in Part II., the reader may be able to select plants to his liking.

The groups which most strongly appeal to the writer as staple or general-purpose types are the following: Petunias, phloxes, pinks or dianthuses, larkspurs or delphiniums, calliopsis or coreopsis, pot marigold or calendula, bachelor's button or Centaurea Cyanus, clarkias, zinnias, marigolds or tagetes, collinsias, gilias, California poppies or eschscholtzias, verbenas, poppies, China asters, sweet peas, nemophilas, portulaccas, silenes, candytufts or iberis, alyssum, stocks or matthiolas, morning-glories, nasturtiums or tropaeolums.



44.—*Zinnias. Often known as "youth and old age."*

Annual flowers possess a great advantage over perennials in the fact that they appeal strongly to the desire for experiment. The seeds are sown every year, and there is sufficient element of uncertainty in the results to make the effort interesting; and new combinations can be tried each year.

Do not cut the old stalks down in the fall. They will stand in the snow all through the winter, and remind you of the bursting summer time and the long-ripening fall; and the snow-birds will enjoy them.

A word with the boys and girls.—Let us make a flower garden next summer! We can make it mornings and evenings, and it shall belong to us alone. We shall own it; and we shall see the rain fall on it and watch the bees and moths collecting the honey from the flowers.

Our garden must be small, for we want a good one. It shall be the best garden in the neighborhood. We shall find a place beside the back fence, or alongside the barn, or in some other out-of-the-way place. It must be in the sunshine, and the eaves must not drip on it.

We shall shake the earth out of the sod and then carry the grass roots away. We shall bring a wheelbarrow load of rich earth from the barn-yard.

I shall make my bed about four feet wide and eight feet long. I do not want it very big, or I shall not have time to go fishing. I do not know what kinds of flowers you want to grow, but I shall plant phlox, petunias, China asters, and, I think, California poppies. By having four kinds, I can have a space two feet wide for each,—that will make a bed four feet by two, of each kind. I wonder which of us will get the most flowers from these beds? Write me in the fall and let me know how many you had.

Let me tell you how to water the plants. I wonder if you have a watering-pot? If you have, put it where you cannot find it, for we are going to water this garden with a rake! We want you to learn, in this little garden, the first great lesson in farming,—how to save the water in the soil. If you learn that much next summer, you will know more than many old farmers do. You know that the soil is moist in the spring when you plant the seeds. Where does this moisture go to? It dries up,—goes off into the air. If we could cover the soil with something, we

45.—*Winter is coming. The evening primrose in seed.*

46.—*A young gardener.*

should prevent the moisture from drying up. Let us cover it with a layer of loose, dry earth! We shall make this covering by raking the bed every few days,—once every week anyway, and oftener than that if the top of the soil becomes hard and crusty, as it does after a rain. Instead of pouring water on the bed, therefore, we shall keep the moisture in the bed.

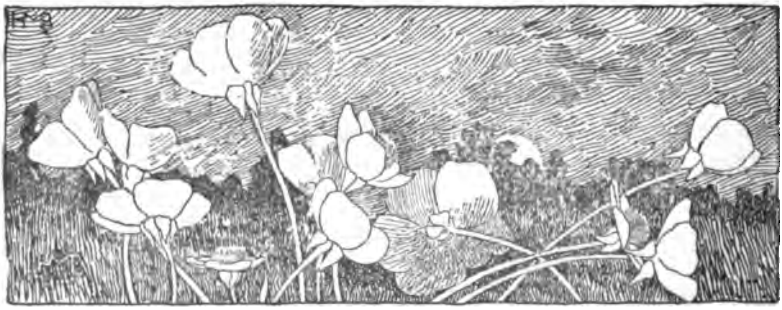
If, however, the soil becomes so dry in spite of you that the plants do not thrive, then water the bed. Do not sprinkle it, but water it. Wet it clear through at evening. Then in the morning, when the surface begins to dry, begin the raking again to keep the water from getting away. Sprinkling the plants every day or two is one of the surest ways to spoil them.

47.—*A window garden.*

48.—*A box garden.*

Perhaps you live in the city, and have no yard. Then you can grow the plants in pots or boxes in the window or on the roof. But plants in pots and boxes needs lots of water.

Why not have a flower show in the school next fall? Ask the teacher about it.



II. STATISTICS OF EASILY-GROWN ANNUALS.

(*G. N. Lauman.*)

In 1897, over four hundred kinds of annual flowers and in 1898 over fifty kinds, not including China asters and sweet peas,* were grown on the grounds of the Horticultural Department of Cornell University. In 1897, most of the seeds were sown May 21, while in 1898 it was June 6 before the seeds were sown. The soil varied somewhat, but it was light and well tilled, and only moderately rich. Both seasons were very wet, and that of 1897 was cold during July and August. The falls of both years were very favorable to continued plant growth, and that of 1898 was spared a frost at the usual time. About 250 other kinds were grown or sown, but they either did not germinate or seemed to be unadapted to general use at this place.

The following table gives the data which were taken from the plants from time to time and summaries are given to facilitate the selection of plants for particular purposes. The names are those in use among seedsmen, and no attempt has been made to revise them to accord with the latest botanical nomenclature.

Annuals are most useful for quick effects, to fill vacant places about shrubbery and in bulb beds. It is generally advisable to sow the seed rather profusely in order to provide against failures, particularly if the ground is dry and not in good tilth. All the annuals here mentioned are very easily grown, and no instructions are needed in this bulletin. If, however, the reader wishes details for their cultivation, the catalogues of the leading seedsmen may be consulted.

This is not the record of a variety test. The effort has been made to give the inquirer, in small compass, those facts about annuals which he chiefly desires to know for practical purposes. Similar information can often be secured from seedsmen's catalogues, and these should always be consulted; but one does not always know to what latitudes, soils and seasons those remarks may apply. The statistics given herewith are the actual records of how the plants behaved at Ithaca, under such fair and common conditions as ninety-nine out of every hundred persons are able and willing to give. A very important part of this record is the fact that the results are comparable: that is, all the plants were grown at the same place and most of them in the same year, whereas statistics of this kind are usually compiled from records made in different places and in different years. Our records are all made directly from the plants themselves, with no consultation of other sources of information.

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*An account of China asters, with remarks on flower beds, is contained in our Bulletin 90. Sweet peas are considered in Bulletins 111 and 127.

These lists emphasize the riches which are now at the disposal of every home-maker, and which the enterprising seedsmen have brought from the ends of the earth. A dollar's selection is sufficient to brighten the home from June until snow. We believe that all the flowers mentioned in the table are suitable for general cultivation in this State.

Explanation of table.—The first column gives the names of plants, the second, date of first bloom, the third, date of full bloom, the fourth, date of last bloom. Plants marked with an asterisk (*) were grown in 1898; all others were grown in 1897. Ju. stands for June, Jl., July, A., August, S., September, O., October. A cross (+) means still in bloom after a hard frost.

The fifth column gives average height and habit of plants:

in. = inches.
s. = strict or erect.
sp. = spreading on ground.
t. = trailing on ground.
c. = tendril climbing.
tw. = twiner.

The sixth column gives colors of flowers in the following abbreviations:

r. = red.
y. = yellow.
d. = dark.
b. = blue.
o. = orange.
s. = striped or spotted.
w. = white.
l. = light.
e. = eye.

Body of color is mentioned first: r. y. e. = red with yellow eye. d. r. = dark red.

Of some varieties, several samples, from different packets, were grown, and these appear as duplicates in the list. The abbreviation fl. pl. stands for *flore pleno*, "flowers double."

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
*1 Abronia umbellata	Jl. 28		O. 28+	13 in. s.	b.	
2 Abronia umbellata grandiflora	Jl. 19	A. 3	O. 18+	6 in. t.	b., w. e.	Good under adverse conditions.
3 Acroclinium album	Jl. 8	Jl. 22	A. 23	16 in. s.	w.	Everlastings. Flowers often ruined by rains.
4 Acroclinium roseum	Jl. 8	Jl. 22	A. 26	17 in. s.	l. r.	
5 Acroclinium, double rose	Jl. 8	Jl. 22	A. 26	17 in. s.	l. r.	
6 Acroclinium, double white	Jl. 8	Jl. 22	A. 23	17 in. s.	w.	
7 Adonis aestivalis	A. 11	A. 17	O. 18+	20 in. s.	d. r. b. e.	Foliage good.
8 Adonis autumnalis	A. 11	A. 21	O. 18+	20 in. s.	r. b. e.	
9 Ageratum Mexicanum album	Ju. 21	Ju. 30	O. 18	31 in. s.	w.	Profuse and continuous bloomers.
10 Ageratum Mexicanum, blue.	Ju. 29	Jl. 28	O. 18	32 in. s.	b.	
11 Ageratum Mexicanum, dwarf blue	Ju. 28	Jl. 21	O. 18	24 in. s.	b.	
12 Agrostemma Coeli-Rosa	A. 18		A. 30			
13 Amarantus Abyssinicus	A. 12	A. 23	S. 16		d. r.	
14 Amarantus atropurpureus	Jl. 10	Jl. 22				Rather coarse but gives good color effects in masses.
15 Amarantus bicolor ruber	Jl. 28	A. 11		40 in. s.		
16 Amarantus cruentus	Jl. 12	Jl. 28				
17 Amarantus tricolor splendens	Jl. 21					
*18 Alyssum, sweet	Jl. 28	A. 14	O. 28	10 in. sp.	w.	
*19 Alyssum, sweet compacta	A. 14	S. 1	O. 28	7 in. sp.	w.	Good for edging.
20 Argemone grandiflora lutea.	Jl. 10	Jl. 24	O. 18+	34 in. s.	y.	
21 Argemone grandiflora	Jl. 10	Jl. 28	O. 18+	34 in. s.	l. y.	Not very profuse bloomer.
*22 Asperula azurea setosa	Jl. 28		S. 21	9 in. s.	w.	Free flowering.
23 Bartonia aurea	Ju. 30	Jl. 22	O. 6	28 in. s.	y.	In exposed position injured by wind.
24 Brachycome iberidifolia	Jl. 20	Jl. 28	O. 18	10 in. s.	b.	Good for edging.
25 Brachycome iberidifolia alba	Jl. 12	Jl. 22	O. 18	13 in. s.	w.	Good for edging.
*26 Browallia Czerwiakowski	A. 16	S. 2	S. 21	13 in. s.	l. b.	
*27 Browallia elata	A. 14	S. 2	S. 21	13 in. s.	b.	
*28 Cacalia	Jl. 22	A. 14	S. 21	14 in. s.	o.	

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
*29 Cacalia scarlet	Jl. 28	A. 16	S. 21	14 in. s.	d. r.	Free flowering, for bedding.
*30 Calandrinia grandiflora	A. 16	S. 3	O. 8	14 in. s.	l. r.	
*31 Calandrinia umbellata elegans	A. 16	S. 1	O. 15	10 in. s.	r.	
32 Calendula officinalis	Jl. 13	Jl. 22	O. 18+	19 in. s.	y.	Pot marigolds. Very profuse bloomers, and of the easiest culture.
33 Calendula officinalis, Meteor	Jl. 13	Jl. 22	O. 18+	20 in. s.	y.	
34 Calendula officinalis, Prince of Orange	Jl. 13	Jl. 22	O. 18+	24 in. s.	o.	
35 Calendula officinalis fl. pl	Jl. 13	Jl. 22	O. 18+	26 in. s.	o.	
36 Calendula pluvialis	Jl. 13	Jl. 20	O. 18+	20 in. s.	w., d. e.	
37 Calendula Pongei	Jl. 20	A. 27	O. 18+	24 in. s.	w.	
38 Calendula sulphurea, fl. pl	Jl. 13	Jl. 22	O. 18+	16 in. s.	y.	
39 Calendula suffruticosa	Jl. 13	Jl. 22	O. 18+	18 in. s.	y.	
40 Calliopsis bicolor marmorata	Jl. 19	Jl. 28	O. 18	22 in. s.	y. br. e.	
41 Calliopsis cardaminifolia	A. 10	A. 17	O. 13	18 in. s.	y. br. e.	Fine for bedding.
42 Calliopsis elegans picta	Jl. 21	Jl. 24	S. 18	24 in. s.	y. br. e.	
*43 Callirrhoe involucrata	Jl. 21	A. 30	O. 28+	7 in. s.	l. r.	For bedding. Bright flowered.
*44 Callirrhoe pedata nona	Jl. 28	A. 30	O. 28+	11 in. s.	r.	
*45 Callirrhoe pedata	Jl. 29	S. 5	O. 28+	21 in. s.	l. r.	
46 Cardiospermum Halicacabm	Jl. 28	A. 3	S. 3	24 in. c.	w.	Not trained to a support.
47 Carduus benedictus	Jl. 28	A. 5	O. 18+	26 in. sp.	y.	Flowers inconspicuous.
48 Centaurea Americana	A. 18	A. 23	S. 15	36 in. s.	d. b.	Curious and attractive buds.
49 Centaurea cyanus. Victoria dwarf compact	Jl. 13	Jl. 21	O. 18+	10 in. s.	b.	Common Bachelor's Buttons. Always desirable.
50 Centaurea cyanus minor Blue	Jl. 8	Jl. 28	O. 18+	18 in. s.	b.	
51 Centaurea Cyanus minor Emperor William	Jl. 7	Jl. 28	O. 18+	24 in. s.	d. b.	
52 Centaurea suaveolens	Jl. 19	A. 3	O. 14	18 in. s.	w.	The "Sweet Sultan." Very showy when in bloom.
53 Centaurea suaveolens	Jl. 13	Jl. 20	A. 17	18 in. s.	y.	

54 Centauridium Drummondii	A.	11	A.	28	O. 18+	36 in. s.	y.	Tree-like in shape. Good.
55 Centranthus macrosiphon	Jl.	21	A.	5	O. 18+	18 in. s.	l. r.	
56 Centranthus macrosiphon albus	A.	3	A.	21	O. 18+	22 in. s.	w.	
57 Centranthus macrosiphon nanus	Jl.	22	A.	11	A. 31	11 in. s.	l. r.	
58 Cerinthe retorta	Jl.	23	Jl.	28	O. 18+	32 in.	y.	Much visited by bees.
59 Cheiranthus Cheiri	Jl.	13	Jl.	20	O. 18+	24 in. s.	d. y.	
60 Chrysanthemum Burridgeanum	Jl.	10	Jl.	21	O. 9	20 in. s.	w., y. e.	
61 Chrysanthemum carinatum eclipse	Jl.	14	Jl.	22	O. 18+	20 in. s.	y.	
62 Chrysanthemum carinatum	Jl.	13	Jl.	28	O. 18	17 in. s.	w., y. e.	
63 Chrysanthemum carinatum	Jl.	13	Jl.	22	O. 18	22 in. s.	y., b. e.	Largest flowers.
64 Chrysanthemum coronarium album	Jl.	13	Jl.	22	O. 18	32 in. s.	w., y. e.	Very minute eye.
65 Chrysanthemum coronarium double yellow	Jl.	13	Jl.	28	O. 18	32 in. s.	y.	All these chrysanthemums are interesting and easy to grow.
66 Chrysanthemum coronarium sulphureum, fl. pl	Jl.	15	Jl.	28	O. 18	26 in. s.	y.	
67 Chrysanthemum tricolor	Jl.	13	Jl.	28	O. 18	25 in. s.	d. r., y. e.	
68 Chrysanthemum tricolor Dunnettii	Jl.	13	Jl.	24	O. 9	22 in. s.	y.	
69 Chrysanthemum tricolor hybridum	Jl.	13	Jl.	22	O. 18	24 in. s.	y., b. e.	
70 Clarkia elegans alba, fl. pl	Jl.	6	Jl.	22	S. 2	36 in. s.	w.	Clarkias are always interesting.
71 Clarkia elegans rosea	Jl.	3	Jl.	22	A. 17	28 in. s.	l. r.	
72 Clarkia elegans rosea, fl. pl.	Jl.	3	Jl.	22	A. 23	30 in. s.	l. r.	
*73 Cleome spinosa	A.	14	A.	20	O. 10	40 in. s.	w.	
74 Collinsia bartsiaefolia	Jl.	6	Jl.	22			d. b.	
75 Collinsia bicolor	Jl.	8	Jl.	22	S. 4	10 in. sp.	d. b., w. s.	Very free flowering.
76 Collinsia bicolor alba	Jl.	6	Jl.	22	S. 13	9 in. sp.	w.	
77 Collinsia candidissima	Jl.	8	Jl.	22	S. 10	9 in. sp.	w.	The collinsias are excellent little herbs.
78 Collinsia multicolor	Jl.	6	Jl.	22			w.	
79 Collinsia multicolor marmorata	Jl.	8	Jl.	22	S. 27	10 in. sp.	b. w.	

Names of plants.	First bloom.	Full bloom.	Full bloom.	Height and habit.	Color.	Remarks.
80 Collomia coccinea	Jl. 22	A. 5	S. 3	13 in.	l. r	.
81 Convolvulus major.........	A. 7	A. 23	S. 15	96 in. tw.	w.	
82 Convolvulus minor	Jl. 8	Jl. 22	O. 18+	15 in. sp.	b.	Dwarf morning glories. All C. minor varieties very profuse bloomers.
83 Convolvulus minor albus...	Jl. 10	Jl. 22	O. 18+	12 in. sp.	w.	
84 Convolvulus minor	Jl. 10	Jl. 22	O. 18+	12 in. sp.	d. b.	
85 Convolvulus minor unicaulis	Jl. 14	A. 3	O. 18+	15 in. sp	b., w. y. e.	
86 Convolvulus tricolor roseus.	Jl. 10	Jl. 22	O. 18+	12 in. sp.	r., y. e.	
*87 Cosmidium Burridgianum	A. 16	S. 5	O. 28	19 in. s.	y., b. c.	Fine for bedding.
88 Cucumis erinaceus, hedgehog gourd..........	Jl. 28	A. 11	S. 1	96 in. c.	w.	Curious fruits which throw their seeds forcibly.
89 Cucumis odoratissimus.....	Jl. 31	A. 12	S. 8	96 in. c.	y.	Gourds are useful for covering waste places.
Cucurbita– Gourds,						
90 Mianature bottle........	Jl. 22	Jl. 28	S. 8	96 in. c.	y.	
91 Dipper................	Jl. 28	A. 10		96 in. c.	y.	
92 Mock orange	Jl. 10	Jl. 28	S. 7	96 in. c.	w.	
93 Spoon................	Jl. 10	Jl. 28	S. 11	96 in. c.	w.	
*94 Sugar trough...........	Jl. 21	A. 7	S. 10	96 in. c.	w.	
95 Cyclanthera pedata	A. 22	S. 3	O. 15	36 in. tw.	w.	
96 Datura cornucopia	Jl. 20			30 in. s.	w.	
97 Datura, fastuosa...........	A. 8	A. 28	O. 18	35 in. s.	w.	Produced triple flowers.
98 Datura, New Golden Queen.	S. 7			36 in. s.	y.	Produced triple flowers.
99 Delphinium, double	A. 5	A. 17	S. 7	18 in. s.	w.	
100 Delphinium	A. 3	A. 12	S. 13	20 in. s.	l. r.	
101 Dianthus, double white Margaret....................	A. 12	S. 15	O. 18+	15 in. s	w.	The dianthuses or pinks have fine colors and fragrance.
102 Dianthus, half dwarf early Margaret	Jl. 26	A. 27	O. 18+	13 in. s.	l. r.	
103 Dianthus, Dwarf Perpetual	A. 12	S. 18	O. 18+	15 in. s.	r.	
104 Dianthus, double white Margaret..................	A. 26		O. 18+	15 in. s.	w.	
105 Dianthus, Comtesse de Paris	A. 26		O. 18+	14 in. s.	y.	

106	Dianthus, double violet Margaret	Jl.	31	A.	28	O. 18+	15 in. s.	d. b.	Foliage continues green through winter. Always desirable.
107	D. caryophyllus semperflorens	A.	26	S.	15	O. 18+	15 in. s.	w.	
108	D. Chinensis, double	Jl.	13	Jl.	22	O. 18+	15 in. s.	w.	
109	D. Chinensis, double	Jl.	19	Jl.	22	O. 18+	15 in. s.	d. r.	
110	D. dentosus hybridus	Jl.	16	Jl.	28	O. 18+	15 in. s.	d. b.	
111	D. Heddewigii, Eastern Queen			Jl.	22	O. 18+	15 in. s.	l. r.	
112	D. Heddewigii, Mourning Cloak	Jl.	31	A.	9	O. 18+	15 in. s.	d. r.	
113	D. Heddewigii, Crimson Belle	Jl.	17	Jl.	28	O. 18+	14 in. s.	r.	
114	D. imperialis, fl. pl.	Jl.	17	Jl.	22	O. 18+	15 in. s.	d. r.	
115	D. imperialis, Dwarf, fl. pl.	Jl.	17	Jl.	22	O. 18+	15 in. s.	w.	
116	D. laciniatus, "Salmon Queen"	Jl.	29	A.	9	O. 18+	13 in. s.	s.	
117	D. plumarius	Jl.	19	Jl.	28	O. 18+	14 in. s.	w.	
118	D. superbus, Dwarf, fl. pl.	Jl.	20	Jl.	28	O. 18+	14 in. s.	w.	
119	Picotee	A.	11	A.	28	O. 18+	14 in. s.	y.	
120	Elscholtzia cristata	Jl.	20				15 in. s.	l. b.	
121	Erysimum Arkansanum	Jl.	10	Jl.	22	O. 18+	30 in. s.	y.	
122	Erysimum Peroffskianum	Jl.	10	Jl.	22	O. 18+	26 in. s.	o.	
123	Eschscholtzia Californica	Jl.	10	Jl.	22	O. 18+	16 in. sp.	y., o. c.	California poppies. Fine for bedding. Profuse flowering. Foliage attractive. Blooms after frost. Excellent.
124	Eschscholtzia C., Rose cardinal	Jl.	10	Jl.	22	O. 18+	15 in. sp.	r.	
125	Eschscholtzia C., alba	Jl.	10	Jl.	22	O. 18+	16 in. sp.	w.	
126	Eschscholtzia crocea plena	Jl.	10	Jl.	22	O. 18+	12 in. sp.	o.	
127	Eschscholtzia, Mandarin	Jl.	13	Jl.	22	O. 18+	14 in. sp.	o.	
128	Eschscholtzia maritima	Jl.	10	Jl.	22	O. 18+	14 in. sp.	y.	
129	Eschscholtzia tenuifolia	Jl.	13	Jl.	22	O. 18+	14 in. sp.	y.	
130	Euphorbia marginata	S.	4	S.	9	O. 18	36 in. s.	w.	Foliage conspicuous. Known as "Snow-on-the-Mountain."
131	Eutoca viscida	Jl.	13	Jl.	22	S. 1	24 in. s.	b.	
132	Eutoca Wrangeliana	Jl.	13	Jl.	22	A. 19	22 in. s.	l. b.	
*133	Gaillardia	Jl.	13	A.	19	O. 28+	13 in. s.	r., d. c.	

	Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
134	Gaillardia picta	Jl. 21	A. 5	O. 18+	14 in. s.	y.	Very showy. Gaillardias should be better known.
*135	Gaillardia picta	A. 16	S. 5	O. 28+	19 in. s.	r., d. c.	
*136	Gaillardia picta Lorenziana	A. 14	S. 5	O. 28+	18 in. s.	y.	
137	Gamolepsis Tagetes	Jl. 13	Jl. 28	S. 13	12 in. s.	y.	
138	Gilia achilleaefolia	Jl. 10	Jl. 16	A. 31	18 in. s.	b.	Very free flowering and attractive.
139	Gilia a. alba	Jl. 6	Jl. 21	O. 18+	15 in. s.	w.	
140	Gilia a. rosea	Jl. 6	Jl. 21	A. 30	20 in. s.	l. r.	
141	Gilia capitata	Jl. 6	Jl. 22	O. 18+	30 in. s.	l. b.	
142	Gilia c. alba	Jl. 6	A. 10	O. 18+	31 in. s.	w.	
143	Gilia laciniata	Jl. 13	A. 7	O. 18+	12 in. s.	l. b.	
144	Gilia linifolia	Jl. 14	Jl. 28	A. 27	12 in. s.	w.	
145	Gilia nivalis	Jl. 10	Jl. 22	S. 8	15 in. s.	w.	
146	Gilia tricolor	Jl. 10	Jl. 22	O. 18 +	18 in. s.	l.b. marg.	
147	Gilia tricolor rosea splendens	Jl. 13	Jl. 22	O. 18 +	20 in. s.	l.r. marg.	
148	Godetia, Bijou	Jl. 22	A. 2	O. 18 +	6 in. s.	l. r.	
149	Godetia, Duchess of Albany	Jl. 22	A. 28	O. 18 +	9 in. s.	w.	Very large flowers.
150	Godetia, Fairy Queen	A. 2	A. 11	O. 18 +	10 in. s.	w.	Very liable to root disease; otherwise to be recommended.
151	Godetia, Lady Albemarle	Jl. 20	Jl. 28	S. 15	8 in. s.	r.	
152	Godetia, Lady Satin Rose	Jl. 20	Jl. 24	O. 18 +	8 in. s.	r.	
153	Godetia, Prince of Wales	Jl. 22	Jl. 28	O. 18 +	10 in. s.	d. r.	
154	Godetia Whitneyi	Jl. 20	Jl. 28	O. 18 +	11 in. s.	d. r.	
155	Godetia W., Brilliant	Jl. 30	A. 5	S. 11	12 in. s.	d. r.	
156	Godetia W., Duke of Fife	Jl. 31	A. 5	S. 13	11 in. s.	l. r.	
157	Godetia grandiflora maculata	Jl. 20	Jl. 24	O. 18 +	10 in. s.	w., r. s.	
158	Godetia rubicunda splendens	Jl. 21	A. 3		11 in. s.	r.	
159	Gypsophila muralis	Jl. 10	Jl. 22	O. 18 +	6 in.	d. b.	
160	Helianthus, Double green centered	Jl. 28	A. 7	S. 8	48 in. s.	y.,	
161	Helianthus, Globe flowered.	A. 12	A. 21	S. 15	52 in. s.	y.,	

162 Helianthus, Dwarf, variegated foliage	A.	7	A.	23	S.	13	46 in. s.	y., br. c.	Sunflowers.
163 Helianthus, Dwarf, Henry Wilde	Jl.	20	Jl.	28	S.	16	72 in. s.	y., br. c.	Flowers large and numerous. Good for backgrounds. Silvery foliage.
164 Helianthus, Single Russian	Jl.	21	Jl.	30	S.	4	84 in. s.	y., br. c.	
165 Helianthus, California dbl	Jl.	31	A.	11	S.	8	60 in. s.	y., br. c.	
166 Helianthus, Dwarf double	Jl.	28	A.	10	S.	13	40 in. s.	y., br. c.	
167 Helianthus, Primrose-color'd	Jl.	21	A.	12	S.	13	62 in. s.	y., br. c.	
168 Helianthus argophyllus	A.	17	A.	28	S.	16	50 in. s.	y., br. c.	
169 Helianthus cucumerifolius	Jl.	22	A.	28			40 in. s.	y., br. c.	
170 Helianthus macrophyllus giganteus	A.	4	A.	21			90 in. s.	y., br. c.	
171 Helichrysum bracteatum	A.	4	A.	17	S.	4	25 in. s.	y.	Everlastings. Large flowers.
172 Helichrysum astrosanguineum	A.	3	A.	26	S.	8	23 in. s.	r. y. c.	
173 Helichrysum macranthum	Jl.	22	A.	11	S.	18	27 in. s.	l. r.	
174 Helipterum corymbiflorum	Jl.	13	Jl.	22	O.	18 +	10 in. s.	w.	Everlastings.
175 Helipterum Sanfordii	Jl.	10	Jl.	22	A.	23	14 in. s.	y.	
176 Hibiscus Africanus	Jl.	15	Jl.	28	S.	18	28 in. s.	y.	
177 Hibiscus, Golden Bowl	Jl.	20	A.	18	S.	30	32 in. s.	l. y.	Fine large flowers and good foliage.
178 Hieracium	Jl.	28	A.	10	S.	6	20 in. s.	w.	
179 Hieracium, Bearded	Jl.	24	A.	17	S.	8	17 in. s.	y.	
180 Humulus Japonicus	A.	17	A.	24	S.	8	96 in. tw.	l. green.	Very numerous inconspicuous flowers. A good vine.
181 Humulus J. variegatus	A.	17	A.	21	S.	10	96 in. tw.	l. green.	
182 Iberis affinis	Jl.	14	Jl.	28	O.	18 +	12 in. s.	w.	Candytuft. Very showy profuse bloomers. Of easiest culture.
183 Iberis amara	Jl.	10	Jl.	22	A.	31	14 in. s.	w.	
184 Iberis coronaria, Empress	Jl.	10	Jl.	22	S.	9	13 in. s.	w.	
185 Iberis c., White Rocket	Jl.	10	Jl.	22	S.	6	13 in. s.	w.	
186 Iberis sweet-scented	Jl.	14	Jl.	24	S.	18	15 in. s.	w.	
187 Iberis umbellata	Jl.	10	Jl.	22	A.	17	14 in. s.	d. r.	
188 Iberis umbellata	Jl.	10	Jl.	22	A.	28	14 in. s.	l. b.	
189 Iberis u. carnea	Jl.	13	Jl.	22	A.	28	14 in. s.	l. r.	
190 Iberis u. lilacina	Jl.	10	Jl.	22	A.	17	13 in. s.	l. b.	
191 Impatiens, Red stalk	A.	3	A.	16	O.	18	30 in. s.	r.	
192 Impatiens, Double	Jl.	24	Jl.	28	O.	18	30 in. s.	w.	

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
193 Impatiens Dbl. Pomegranate	Jl. 22	Jl. 28	O. 18	30 in. s.	r.	Balsams. Very profuse bloomers of fine color. Well known and popular.
194 Impatiens Dbl. Pomegranate	Jl. 21	Jl. 28	O. 18	30 in. s.	l. y.	
195 Impatiens Dbl. Pomegranate	Jl. 24	A. 2	O. 18	30 in. s.	w., b. s.	
196 Impatiens Dbl. Pomegranate	Jl. 22	Jl. 28	O. 18	30 in s.	d. b.	
197 Impatiens Dbl. Pomegranate	Jl. 21	Jl. 28	O. 18	30 in. s.	w. & l. b.	
198 Impatiens double	Jl. 21	Jl. 28	O. 18	30 in. s.	w.	
199 Impatiens double	Jl. 21	Jl. 28	O. 18	30 in. s.	l. r.	
200 Impatiens double	Jl. 22	Jl. 28	O. 18	30 in. s.	r., w. s.	
201 Impatiens camellia-flowered	Jl. 20	Jl. 28	O. 18	30 in. s.	r.	
202 Impatiens camellia-flowered	Jl. 25	Jl. 31	O. 18	30 in. s.	l. b.	
203 Impatiens camellia-flowered	Jl. 21	Jl. 28	O. 18	30 in. s.	d. b.	
204 Impatiens camellia-flowered	Jl. 21	Jl. 28	O. 18	30 in. s.	w., r. s.	
*205 Ipomœa coccinea	A. 16	S. 5	O. 28	96 in. tw.	r., d. c.	Morning Glories. Always excellent. Fine in foliage and flower.
206 Ipomœa coccinea lutea	Jl. 13	A. 26	S. 27	96 in. tw.	y.	
*207 Ipomœa scarlet	A. 15	S. 5	O. 28	96 in. tw.	l. r.	
*208 Ipomœa hederacea	A. 24	S. 15	S. 28	96 in. tw.	w.	
*209 Ipomœa hederacea	A. 24	S. 10	S. 28	48 in. tw.	w.	
210 Ipomœa hederacea marmorata	Jl. 14	A. 10	S. 18	96 in. tw.	l. b.	
211 Ipomœa limbata	Jl. 10	A. 12	S. 27	96 in. tw.	b., w. s.	
*212 Ipomœa limbata	A. 23	S. 3	S. 28	96 in. tw.	l. r.	
213 Ipomœa Nil	Jl. 10	A. 28	S. 27	96 in. tw.	b.	
*214 Ipomœa purpurea			S. 28	96 in. tw.	w. s. l.	
*215 Ipomœa volubilis	A. 23	S. 17	S. 28	96 in. tw.	r.	
*216 Ipomœa volubilis	A. 23	S. 1	S. 28	96 in. tw.	d. r.	
*217 Ipomœa volubilis	A. 23	S. 15	S. 28	96 in. tw.	d. r.	
218 Kaulfussia amelloides	Jl. 13	Jl. 22	A. 13	8 in. s.	b.	Fine, but of short duration.
219 Kaulfussia a. atroviolacea	Jl. 21	Jl. 28	A. 28	9 in. s.	b.	
220 Kaulfussia a. kermesina	Jl. 21	Jl. 31	A. 16	9 in. s.	b.	
221 Lagenaria vulgaris, Bottle gourd	Jl. 31	A. 12	S. 13	96 in. c.	w.	

222	Lavatera alba	Jl. 22	Jl. 28	O. 18+	40 in. s.	w.	
223	Lavatera trimestris	Jl. 21	A. 3	O. 18	36 in. s.	l. r.	Large cup-shaped flowers.
224	Leptosiphon androsaceus	Jl. 13	Jl. 22	S. 18	12 in. s.	w.	
225	Leptosiphon carmineus	Jl. 13	Jl. 22	S. 13	14 in. s.	d. r.	
226	Leptosiphon densiflorus	A. 2	A. 5	S. 8	10 in. s.	b.	Good for edging.
227	Leptosiphon d. albus	Jl. 21	Jl. 28	S. 30	12 in. s.	w.	
228	Leptosiphon hybridus	Jl. 10	Jl. 22	O. 1	8 in. s.	w.	
229	Linaria bipartita splendida	Jl. 15	Jl. 30	S. 18	9 in. s.	d. b.	
230	Linaria Maroccana		Jl. 22	A. 16	8 in. s.	r.	
231	Linum grandiflorum	Jl. 21	A. 28	O. 18	21 in. sp.	r.	Dense, bushy foliage.
232	Loasa tricolor	Jl. 20	Jl. 3	A. 31	22 in. sp.	y.	Curious flowers and foliage.
*233	Lobelia Erinus	Jl. 29		O. 28	8 in. sp.	l. b.	
*234	Lobelia Erinus, Elegant	A. 14	S. 1	O. 28	8 in. sp.	l. b.	Good for edging.
235	Lupinus albus	Jl. 13	Jl. 22	S. 18	21 in. s.	w.	
236	Lupinus hirsutus	Jl. 13	Jl. 28	S. 18	20 in. s.	r.	
237	Lupinus h. pilosus	Jl. 13	Jl. 28	S. 27	25 in. s.	b.	
238	Lupinus nanus	Jl. 28	A. 10	O. 18	15 in. s.	l. b.	
239	Lupinus pubescens	Jl. 13	A. 28	O. 18	20 in. s.	w.	
240	Lupinus sulphureus	Jl. 13	A. 2	O. 18	16 in. s.	y.	
241	Madia elegans	Jl. 28	A. 3	O. 18	36 in. s.	y., b. e.	Very numerous conspicious flowers.
242	Malope grandiflora	Jl. 14	Jl. 28	O. 18	15 in. s.	w. l. r.s.	Numerous mallow-like flowers.
243	Malope g. alba	Jl. 14	Jl. 28	O. 18	18 in. s.	w.	
244	Martynia craniolaria	Jl. 13	Jl. 21		36 in. s.	w., r. s.	Curious flowers and fruit.
245	Martynia formosa	Jl. 13	Jl. 21		36 in. s.	w.	
246	Martynia lutea	Jl. 15	Jl. 24		36 in. s.	y.	
247	Martynia proboscidea	Jl. 10	Jl. 24		36 in. s.	w. l.b.s.	
248	Matricaria eximia plena	A. 14	A. 28	S. 17	22 in. s.	w.	
249	Matthiola crimson	Jl. 13	Jl. 22	O. 18+	23 in. s.	r.	
250	Matthiola, Blood Red Ten Weeks	Jl. 13	Jl. 22	O. 18+	26 in. s.	d. r.	Stocks.
251	Matthiola, Cut and Come Again	Jl. 13	Jl. 22	O. 18+	25 in. s.	w.	Excellent for massing.
252	Matthiola, White Pearl	Jl. 15	Jl. 28	O. 18+	18 in. s.	w.	Fragrant. At their best in mid-
253	Matthiola grandiflora	Jl. 13	Jl. 22	S. 18+	24 in. s.	y.	season.
254	Matthiola grandiflora Dwarf	Jl. 14	Jl. 22	O. 18+	23 in. s.	r.	

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
255 Matthiola Light Blue	Jl. 13	Jl. 22	O. 18+	24 in. s.	l. b.	Stocks are always popular and worthy.
256 Matthiola Shining	Jl. 13	Jl. 22	O. 18+	23 in. s.	r.	
257 Matthiola, Giant Perfection	Jl. 9	Jl. 21	O. 18+	18 in. s.	w.	
258 Matthiola, Dresden Perpetual	Jl. 13	Jl. 22	O. 18+	23 in. s.	w.	
259 Matthiola, Double White Perfection	Jl. 13	Jl. 20	O. 18+	23 in. s.	w.	
260 Matthiola, Dwarf	Jl. 13	Jl. 22	O. 18+	24 in. s.	l. r.	
261 Matthiola, annuus	Jl. 13	Jl. 22	O. 18+	24 in. s.	r.	
262 Matthiola, Dwarf Forcing Snowflake	Jl. 15	Jl. 22	O. 18+	12 in. s.	w.	
263 Matthiola, Dwarf	Jl. 13	Jl. 22	S. 27	20 in. s.	l. r.	
264 Matthiola, Dwarf, Large-flowering	Jl. 14	Jl. 22	O. 18+	20 in. s.	w.	
265 Matthiola, Dwarf, Large-flowering	Jl. 15	Jl. 22	O. 18+	24 in. s.	w.	
266 Matthiola, Wallflower-leaved	Jl. 13	Jl 22	S. 30	11 in. s.	w.	
267 Matthiola, Wallflower-leaved	Jl. 13	Jl. 22	O. 18+	16 in. s.	r.	
268 Virginian Stock, Crimson King	Jl. 15	Jl. 22	O. 2	17 in. sp.	r.	
269 Virginian Stock	Jl. 13	Jl. 22	O. 18+	14 in. sp.	w.	Distinct from the ordinary stock.
270 Virginian Stock	Jl. 13	Jl. 22	O. 18+	14 in. sp.	l. r.	
271 Matthiola, biconis	Jl. 13	Jl. 21	S. 15	18 in. sp.	w.	
272 Mesenbryanthemum crystallinum	Jl. 30	A. 28	S. 18	10 in. sp.	w.	Curious plant. Inconspicuous flowers.
*273 Mimulus cupreus	Jl. 26	A. 14		9 in. sp.	w.	
274 Mirabilis alba	Jl. 28	A. 3	S. 30	15 in. s.	w.	The Four O'clocks; old and well known
275 Mirabilis Jalapa folio variegata	Jl. 28	A. 5	S. 28	26 in. s.	w.	
276 Mirabilis longiflora alba	Jl 30	A. 6	S. 30	26 in. s.	w.	
*277 Momordica elaterium	Jl. 25	A. 14	O. 28	13 in. sp.	y.	Fruits conspicuous and interesting.

278 Nigella	Jl. 21	Jl. 28	S. 2	16 in. s.	b.	Very fine in foliage and flower.
279 Nigella	Jl. 30	A. 3	S. 27	12 in. s.	w.	
280 Nigella, fl. pl	Jl. 21	Jl. 28	S. 1	16 in. s.	w.	
281 Nemophila atomaria	Jl. 13	Jl. 28	A. 28	6 in. sp.	w.	
282 Nemophila a. oculata	Jl. 14	Jl. 28		10 in. sp.	b.	Nemophilas are good for edgings. Pretty.
283 Nemophila discoidalis	Jl. 14	A. 2	A. 21	5 in. sp.	d. b.	
284 Nemophila insignis	Jl. 13	Jl. 24	O. 18	6 in. sp.	b., w. e.	
285 Nemophila i. alba	Jl. 14	Jl. 28	O. 18	8 in. sp.	w.	
286 Nemophila maculata	Jl. 13	Jl. 24	A. 28	6 in. sp.	s.	
287 Nemophila marginata	Jl. 13	Jl. 24		10 in. sp.	b., w. e.	
*288 Nolana atriplicifolia	Jl. 12	Jl. 29	O. 1	8 in. sp.	l. b.	Stems and leaves fleshy. Make attractive mats on the ground.
*289 Nolana atriplicifolia	Jl. 12	Jl. 29	O. 5	9 in. sp.	w.	
290 Nolana atriplicifolia alba	Jl. 15	Jl. 28		7 in. t.	w.	
291 Nolana lanceolata	A. 28			6 in. t.	b.	
292 Nolana paradoxa	A. 1			6 in. t.	b.	
*293 Nolana prostrata	Jl. 11	A. 14	O. 5	8 in. sp.	b.	
294 Omphalodes linifolia	Jl. 13	Jl. 22	S. 1	10 in. s.	w.	
*295 Oenothera Drummondii	A. 14	S. 5	O. 28	20 in. s.	y.	Flowers open at night.
*296 Oenothera Lamarckiana	S. 3		O. 28+	13 in. s.	y.	
*297 Oenothera rosea	Jl. 29	A. 30	O. 28+	12 in. s.	l. r.	
*298 Omothera tetraptera	Jl. 15	A. 18	O. 28+	10 in. s.	l. r.	
299 Palafoxia Hookeriana	Jl. 21	A. 3	A. 28	13 in. s.	l. r.	Everlasting.
300 Papaver, American Flag	Jl. 20	Jl. 24	S. 3	24 in. s.	r. and w.	Poppies. Bedding plants. Large showy flowers. Long stem on flowers.
301 Papaver, Flag of Truce	Jl. 20	Jl. 24	A. 28	22 in. s.	w.	
302 Papaver, Irresistible	Jl 20	Jl. 28	A. 30			
303 Papaver, Mephisto	Jl. 19	Jl. 24	A. 31	20 in. s.	r.	
304 Papaver, The Mikado	Jl. 20	Jl. 28	A. 28	30 in. s.	w.	
305 Papaver, Double	Jl. 19	Jl. 24	A. 27	26 in. s.	r.	
306 Papaver, Shirley	Jl. 13	Jl. 20	A. 20	15 in. s.	w.	
307 Papaver cardinale	Jl. 22	Jl. 28	A. 30	18 in. s.	r.	
308 Papaver c. hybridiun	Jl. 19	Jl. 28	A. 27	21 in. s.	l. r.	
309 Papaver c., Danebrog	Jl. 19	Jl. 22	A. 23	20 in. s.	r.	
310 Papaver glaucum	Jl. 13	Jl. 21	A. 7	15 in. s.	r.	
311 Papaver umbrosum	Jl. 19	Jl. 22	A. 28	18 in. s.	r.	
312 Perilla laciniata	A. 18	A. 21		30 in. s.		

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
313 Perilla Nankinensis	A. 20	A. 26		27 in. s.		Foliage plants. Bronze-colored.
314 Petunia, Ring of Emerald	Ju. 28	Jl. 3	O. 9	14 in. sp.	d. b. and gr'n edge	
315 Phaseolus multiflorus	Jl. 13	Jl. 22	S. 27	96 in. tw.	r.	Very vigorous.
Phlox Drummondii :—						
316 Phlox, Large flowering dwarf	Jl. 14	Jl. 24	O. 18+	12 in. sp.	d. r.	Bedding and border plants. Very profuse and long-flowering. Easy to grow.
317 Phlox, Dwarf Fireball	Jl. 20	Jl. 28	O. 18+	14 in. sp.	r.	
318 Phlox, Dwarf Bouquet	Jl. 20	Jl. 28	O. 18+	14 in. sp.	r.	
319 Phlox, Dwarf Snowball	Jl. 24	A. 3	O. 18+	12 in. sp.	w.	
320 Phlox grandiflora, half dwarf	Jl. 13	Jl. 24	O. 18+	15 in. sp.	br.	
321 Phlox, Black Warrior	Jl. 13	Jl. 22	O. 18+	15 in. sp.	d. r.	
322 Phlox, Rose	Jl. 15	Jl. 22	O. 18+	15 in. sp.	l. r.	
323 Phlox, Leopoldii	Jl. 13	Jl. 22	O. 18+	15 in. sp.	w and r.	
324 Phlox oculata alba	Jl. 15	Jl. 28	O. 18+	15 in. sp.	l. b., w. e.	
325 Phlox variabilis atropurpurea	Jl. 20	Jl. 24	O. 18+	15 in. sp.	b.	
326 Phlox grandiflora alba	Jl. 13	Jl. 22	O. 18+	15 in. sp.	w.	
327 Phlox grandiflora, Chamois Rose	Jl. 19	Jl. 24	O. 18+	15 in. sp.	l. r.	
328 Phlox grandiflora, Eclipse		Jl. 28	O. 18+	15 in. sp.	b.	
329 Phlox grandiflora kermesina splendens	Jl. 14	Jl. 24	O. 18+	15 in. sp.	d. r.	
330 Phlox g. stellata splendens.	Jl. 19	Jl. 24	O. 18+	15 in. sp.	r.	
331 Phlox cuspidata	Jl. 14	Jl. 24	O. 18+	15 in. sp.		
332 Podolepis affinis	Jl. 22	A. 2		8 in. sp.	y.	
333 Podolepis chrysantha	Jl. 16	A. 12	O. 18+	7 in. sp.	y.	
334 Portulaca, Carnation striped	Jl. 18	Jl. 28	O. 3	8 in. sp.	r. s.	Edging and bedding plants. Free-flowering. Flowers open in sunlight; need dry soil.
335 Portulaca, fl. pl	A. 9	A. 26	O. 3	8 in. sp.	d. y.	
336 Portulaca, fl. pl	A. 10	A. 17	O. 3	8 in. sp.	d. b.	
337 Portulaca, fl. pl	A. 9	A. 28	O. 3	8 in. sp.	l. r.	
338 Portulaca, fl. pl	A. 9	A. 16	O. 3	8 in. sp.	l. r. s.	
339 Portulaca, fl. pl	Jl. 16	Jl. 28	O. 3	8 in. sp.	d. r.	

340 Portulaca fl. pl.	A. 10	A. 27	O. 3	8 in. sp.	w.	
341 Portulaca albiflora	A. 9	A. 17	O. 3	8 in. sp.	w.	
342 Portulaca aurantiaca	A. 10	A. 17	O. 3	8 in. sp.	y.	
343 Rhodanthe maculata	A. 5	A. 12	S. 27	10 in. s.	r. and w.	Everlastings.
344 Rhodanthe m. alba	Jl. 16	A. 5	A. 30	9 in. s.	w.	
345 Rhodanthe Manglesii	Jl. 21	Jl. 28	A. 28	8 in. s.	r. and w.	
*346 Ricinus albus	Castor beans.			72 in. s.		Light green stems, foliage slightly darker.
*347 Ricinus communis				78 in. s.		Light green foliage, still lighter stems.
*348 Ricinus communis				66 in. s.		Dark green foliage, reddish stems.
*349 Ricinus Gibsoni				60 in. s.		Rich brownish red foliage.
*350 Ricinus sanguineus				72 in. s.		Light green foliage with red stems.
*351 Ricinus viridis				78 in. s.		Dark green foliage, reddish stems.
*352 Ricinus Zanzibariensis				72 in. s.		Light green foliage and stems.
*353 Salvia coccinea	A. 20	S. 5	O. 28+	32 in. s.	r.	Very fine for bedding.
*354 Salvia farinacea	A. 14	S. 5	O. 28+	30 in. s.	l. b.	
*355 Salvia Horminum	Jl. 28	A. 14	O. 28+	15 in. s.	l. r.	
*356 Salvia splendens	A. 14	S. 5	O. 28		d. r.	
357 Saponaria	Jl. 28	A. 17	O. 18	9 in. s.	r.	Numerous small flowers.
358 Saponaria Calabrica	Jl. 28	A. 17	O. 18	10 in. s.	r.	Very compact plants.
359 Schizanthus papilionaceus	Jl. 8	Jl. 22	S. 18	16 in. s.	b. e.	
360 Schizanthus pinnatus	Jl. 8	Jl. 22	S. 27	17 in. s.		Fine in foliage and flower.
361 Sedum coeruleum	Jl. 20	Jl. 24	S. 15	6 in. sp.	w.	Free-flowering.
*362 Schizanthus pinnatus	Jl. 15		O. 5	12 in. sp.	w.	
363 Silene Armeria	Jl. 10	Jl. 22	S. 3	10 in. sp.	r.	
364 Silene A. alba	Jl. 10	Jl. 22		10 in. sp.	w.	Good for bedding.
365 Silene pendula	Jl. 14	Jl. 29		10 in. sp.	r.	
366 Silene p. ruberrima	A. 26		S. 18	7 in. sp.	l. r.	
367 Specularia	Jl. 13	Jl. 28	O. 18	10 in. sp.	b.	Edging plants.
368 Statice superba	Jl. 20		O. 3	14 in. s.	w.	
*369 Statice Thouini	Jl. 12	A. 14		15 in. s.	w.	For bedding.
370 Tagetes, Eldorado	A. 3	A. 28	O. 5	24 in. s.	y.	Marigolds.
371 Tagetes, Pride of the Garden	Jl. 24	A. 2	O. 5	14 in. s.	y.	
372 Tagetes, dwarf	Jl. 13	A. 12	O. 5	13 in. s.	y. s.	

	Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
373	Tagetes, French	Jl. 13	A. 30	O. 5	30 in. s.	o.	Showy plants; color confined to yellow.
374	Tagetes, Nugget of Gold	A. 16		O. 5	24 in. s.	d. y.	
375	Tagetes erecta fl. pl.	A. 23	S. 3	O. 5	27 in. s.	y.	
376	Tagetes patula	Jl. 10	Jl. 24	O. 5	20 in. s.	y. s.	
377	Tagetes signata	Jl. 22	A. 12	O. 5	20 in. s.	l. y.	
378	Thunbergia alata	Jl. 30	A. 11	S. 27	60 in. tw.	w.	Twining plants with numerous small flowers. Good and interesting.
379	Thunbergia a. Bakeri	Jl. 31	A. 11	S. 18	60 in. tw.	w.	
380	Thunbergia a. Fryeri.	A. 2	A. 12	S. 27	60 in. tw.	d. y.	
381	Thunbergia a. aurantiaca	Jl. 28	A. 12		60 in. tw.	d. y.	
382	Thunbergia a. sulphurea	Jl. 28	A. 17	S. 27	60 in. tw.	y.	
383	Tropaeolum dwarf, Tom Thumb	Jl. 8	Jl. 17	O. 18	13 in. sp.	d. r.	Nasturtiums. The "Tom Thumb" or dwarf varieties fine for bedding. Foliage and flowers good.
384	Tropaeolum dwarf	Jl. 7	Jl. 17	O. 18	13 in. sp.	r.	
385	Tropaeolum dwarf	Jl. 8	Jl. 17	O. 18	13 in. sp.	l. r.	
386	Tropaeolum dwarf	Jl. 13	Jl. 21	O. 18	13 in. sp.	very d.r.	
387	Tropaeolum dwarf, Ruby King	Jl. 8	Jl. 17	O. 18	13 in. sp.	d. r.	
388	Tropaeolum dwarf, Aurora	Jl. 7	Jl. 17	O. 18	13 in. sp.	l. r.	
389	Tropaeolum dwarf	Jl. 7	Jl. 17	O. 18	13 in. sp.	w.	
390	Tropaeolum dwarf, Lady Bird	Jl. 7	Jl. 21	O. 18	13 in. sp.	y.	
391	Tropaeolum dwarf, Crystal Palace Gem	Jl. 6	Jl. 17	O. 18	13 in. sp.	l. r.	
392	Tropaeolum dwarf	Jl. 6	Jl. 17	O. 18	13 in. sp.	l. r.	
393	Tropaeolum dwarf, Empress of India	Jl. 8	Jl. 17	O. 18	13 in. sp.	y.	
394	Tropaeolum dwarf	Jl. 6	Jl. 17	O. 18	13 in. sp.	l. y.	
395	Tropaeolum tall	Jl. 10	Jl. 22	O. 18	60 in. tw.	d. r.	
396	Tropaeolum tall	Jl. 10	Jl. 21	O. 18	60 in. tw.	d. y.	
397	Tropaeolum tall	Jl. 10	Jl. 22	O. 18	60 in. tw.	l. r.	
398	Tropaeolum tall, Schulzi	Jl. 13	Jl. 22	O. 18	60 in. tw.	y.	
399	Tropaeolum tall, Schillingi.	Jl. 10	Jl. 21	O. 18	60 in. tw.	l. y.	

400	Tropaeolum tall	Jl.	10	Jl.	21	O. 18	60 in. tw.	y.	The tall kinds are amongst the best of climbing plants, and are particularly good for foliage effects; excellent for covering rough and waste places.
401	Tropaeolum Lobbianum, Asa Gray	Jl.	13			O. 18	60 in. tw.	w.	
402	Tropaeolum L., Brilliant	Jl.	13	Jl.	22	O. 18	60 in. tw.	d. r.	
403	Tropaeolum L., Crown Prince of Prussia	Jl.	13	Jl.	22	O. 18	60 in. tw.	d. r.	
404	Tropaeolum L., Crystal Palace	Jl.	13	Jl.	22	O. 18	60 in. tw.	l. r.	
405	Tropaeolum L., fulgeus	Jl.	10	Jl.	22	O. 18	60 in. tw.		
406	Tropaeolum L., Lilli Smith	Jl.	10	Jl.	22	O. 18	60 in. tw.	d. r.	
407	Tropaeolum L., Lucifer	Jl.	10	Jl.	22	O. 18	60 in. tw.	d. r.	
408	Tropaeolum Lobbianum	Jl.	13	Jl.	21	O. 18	60 in. tw.	d. r.	
409	Tropaeolum L., Queen Victoria	Jl.	10	Jl.	22	O. 18	60 in. tw.	r.	
410	Tropaeolum L., Spit-fire	Jl.	13	Jl.	22	O. 18	60 in. tw.	r.	
411	Tropaeolum majus	Jl.	13	Jl.	22	O. 18	60 in. tw.	r.	
412	Tropaeolum m., hemisphæricum	Jl.	8	Jl.	21	O. 18	60 in. tw.	d. y.	
413	Tropaeol'm m., Schuerianum	Jl.	10	Jl.	20	O. 18	60 in. tw.	s.	
414	Tropaeolum m.S., coccineum	Jl.	13	Jl.	22	O. 18	60 in. tw.	r.	
415	Tropaeolum, Mad. Gunter hybrids	Jl.	13	Jl.	21	O. 18	60 in. tw.		
416	Tropaeolum Canariense	Jl	13	Jl.	21	O. 18	96 in. tw.	y.	
417	Venidium calendulaceum	Jl.	10	Jl.	28	O. 18	15 in. sp.	y.	Somewhat succulent plant.
418	Verbena auriculæflora	Jl.	6	Jl.	22	O. 18—	15 in. sp.		
419	Verbena Italica striata	Jl.	6	Jl.	22	O. 18—	15 in. sp.	s.	Profuse flowering and of fine color
420	Verbena hybrida	Jl.	6	Jl.	22	O. 18—	16 in. sp.	d. r.	
421	Verbena h., Scarlet Defiance	Jl.	6	Jl.	22	O. 18—	15 in. sp.	r.	
422	Verbena, Black-blue	Jl.	6	Jl.	22	O. 18—	15 in. sp.	d.b., w.e.	
423	Verbena cœrulea	Jl.	6	Jl.	22	O. 18—	13 in. sp.	b., w. e.	Bedding plants.
424	Verbena Golden-leaved	Jl.	6	Jl.	22	O. 18—	7 in. sp.	b.	
425	Verbena	Jl.	6	Jl.	22	O. 18—	7 in. sp.	y.	
426	Vicia Gerardii	Jl.	16	Jl.	30	O. 18	22 in. c.	b.	Delicate foliage and good flowers
427	Viscaria Coeli-Rosa	Jl.	16	Jl.	28	O. 18—	14 in. s.	l. r.	Fine foliage and free flowering Bedding plants.
428	Viscaria elegans picta	Jl.	15	Jl.	22	O. 18—	13 in. s.	l. r., d. e.	
429	Viscaria oculata	Jl.	15	Jl.	22	O. 18—	13 in. s.	r., d. e.	

Names of plants.	First bloom.	Full bloom.	Last bloom.	Height and habit.	Color.	Remarks.
430 Viscaria o., alba	Jl. 14	Jl. 22	O. 18—	14 in. s.	w.	
431 Viscaria o., cœrulea	Jl. 14	Jl. 22	O. 18—	12 in. s.		Bell-shaped flowers. Pretty.
432 Whitlavia gloxinoides	Jl. 10	Jl. 22	A. 28	16 in. s.	b. and w.	
433 Whitlavia grandiflora	Jl. 10	Jl. 22	S. 15	18 in. s.	d. b.	
434 Whitlavia g. alba	Jl. 10	Jl. 22	A. 31	19 in. s.	w.	
435 Xeranthemum album	Jl. 24	A. 3	O. 18	21 in. s.	w.	Everlastings.
436 Xeranthemum annuum	Jl. 22	A. 3	O. 18	24 in. s.	d. b.	
437 Xeranthemum multiflorum	Jl. 24	A. 3	O. 18	22 in. s.	b.	
438 Xeranthemum m., album	Jl. 22	Jl. 28	O. 18	23 in. s.	w.	
439 Xeranthemum superbissimum, fl. pl	Jl. 21	A. 2	O. 18	24 in. s.	d. b.	
440 Zinnia dwarf, fl. pl	Jl. 13	Jl. 22	O. 18	21 in. s.	r.	Very profuse-flowering, bedding plants. Excellent for making heavy masses of color in the farther borders. The large kinds are coarse. Showy.
441 Zinnia dwarf, fl. pl	Jl. 13	A. 2	O. 18	18 in. s.	d. b.	
442 Zinnia dwarf, fl. pl	A. 11	A. 26	O. 18	20 in. s.	s.	
443 Zinnia dwarf, fl. pl	Jl. 13	Jl. 28	O. 18	20 in. s.	d. r.	
444 Zinnia dwarf, fl. pl	Jl. 30	A. 5	O. 18	18 in. s.	r.	
445 Zinnia dwarf, fl. pl	Jl. 13	Jl. 22	O. 18	22 in. s.	w.	
446 Zinnia elegans alba, fl. pl	Jl. 28	A. 12	O. 18	26 in. s.	w.	
447 Zinnia, Tom Thumb	Jl. 13	Jl. 28	O. 18	20 in. s.	o.	
448 Zinnia, Tom Thumb	Jl. 13	Jl. 28	O. 18	23 in. s.	w.	
449 Zinnia Haageana, fl. pl	Jl. 14	Jl. 28	O. 18	21 in. s.	y.	
450 Zinnia coccinia plena	Jl. 13	A. 3	O. 18	20 in. s.	d. r.	
451 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	d. r.	
452 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	r.	
453 Zinnia tall, fl. pl	Jl. 16	A. 9	O. 18	23 in. s.	l. r.	
454 Zinnia tall, fl. pl	Jl. 13	A. 3	O. 18	23 in. s.	b.	
455 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	d. b.	
456 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	l. r.	
457 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	d. y.	
458 Zinnia tall, fl. pl	Jl. 13	Jl. 22	O. 18	23 in. s.	b.	
459 Zinnia tall, fl. pl	Jl. 10	Jl. 22	O. 18	23 in. s.	y.	

Summaries.

The various flowers mentioned in the foregoing tables are here classified for the convenience of the cultivator. In the color groups, those kinds which have given most satisfaction at Ithaca are printed in Italics; and these judgments are made with the coöperation of C. E. Hunn, gardener to the Horticultural Department.

Blue flowers.—Nos. *1*, *2*, *10*, *11*, 24, *26*, *27*, *49*, *50*,51, 79, *82*, 84, *85*, 106, 110, 120, 131, 132, *138*, 141, *143*, 146, 159, *188*, *190*, 196, 202, 203, 204, 210, 211, 213, 218, *219*, 220, 229, *233*, *234*, 237, 238, 255, *278*, 282, 283, 284, 287, 288, 291, 292, 293, 314, 324, *325*, 328, 336, *354*, *367*, *422*, *423*, *424*, 426, *432*, 433, 436, 437, 439, 441, 454, 455, 458.

Orange flowers.—Nos. 28, 34, 35, 122, 126, 127, 373, 447.

Red flowers.—Nos. 4, 5, 7, 8, 13, *29*, 30, 31, 43, 44, 45, 55, 57, 67, *71*, *72*, 80, *86*, 100, *102*, *103*, *109*, 111, 112, 113, 114, 124, 133, *135*, 140, 147, 148, 151, 152, 153, 154, 155, 156, 158, 172, 173, 187, 189, 191, 193, 199, 200, 201, *205*, 209, 212, 215, *216*, 217, 223, 225, 230, 231, 236, 249, *250*, *254*, 256, 260, *261*, 263, 267, 268, 270, 297, 298, 299, *303*, *305*, *307*, 308, 309, 310, 311, *315*, *316*, *317*, 318, 320, *321*, 322, 327, 329, 330, 334, 337, 338, 339, *353*, 355, 356, *357*, 358, 363, 365, 366, *383*, *384*, *385*, 386, 387, 388, 391, 392, 395, 397, 402, 403, 404, 406, 407, 408, 409, 410, 411, 414, *420*, *421*, 427, 428, 429, *440*, *443*, 444, 450, 451, 452, 453, 456.

White flowers.—Nos. 3, 6, *9*, *18*, *19*, 22, 25, 36, 37, 46, 52, *56*, 60, 62, 64, 70, 73, 76, 77, 78, *81*, 83, 88, 92, 93, 94, 95, 96, 97, 99, *101*, *104*, 107, *108*, 115, 117, 118, 125, 130, 139, 142, 144, 145, 149, 150, 157, 174, 178, 182, *183*, 184, *185*, 186, 192, 195, 197, 198, 204, *208*, *209*, 221, *222*, 224, 227, 228, 235, 239, 242, *243*, 244, 245, 247, 248, *251*, *252*, *257*, *258*, 259, 262, 264, 265, 266, 269, 271, 272, 273, 274, 275, *276*, *279*, 280, 281, 285, 289, 290, 294, *301*, *304*, *306*, *319*, *323*; 326, 340, 341, 344, 361, 362, 364, 368, 369, 378, 379, 389, 401, 430, *434*, 435, 438, 445, 446, 448.

Yellow flowers.—Nos, 20, 21, 23, *32*, *33*, *38*, *39*, *40*, *41*, *42*, 47, 53, 54, 58, 59, 61, 63, 65, 66, 68, 69, *87*, 89, 90, 91, 98, 105, 119, 121, *123*, 128, 129, 134, 136, 137, 160–171, 175, *176*, *177*, 179, 194, *206*, *232*, 240, 241, 246, 253, 277, 295, 296, 332, 333, 342, *370*, 371, 372, 374, 375, 376, 377, *380*, *381*, 382, *390*, 393, 394, 396, *398*, 399, 400, 412, 416, 417, 425, 449 *457*, *459*.

Climbers.—Nos. 46, 81, 88–95 inclusive, 180, 181, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 221, 315, 378, 379, 380, 381, 382, 395–416 inclusive, 426.

Plants six to eight inches high.—Nos. 2, 148, 159, 281, 283, 284, 286, 291, 292, 361; 19, 43, 290, 333, 366, 424, 425; 151, 152, 218, 228, 230, 233, 234, 285, 288, 293, 332, 334–342 inclusive, 345.

Nine to twelve inches high.—Nos. 22, 76, 77, 149, 219, 220, 229, 273, 289, 344, 357 ; 18, 24, 31, 49, 75, 79, 150, 153, 157, 174, 226, 272, 282, 287, 294, 298, 343, 358, 363, 364, 365, 367 ; 44, 57, 154, 156, 158, 266 ; 83, 84, 86, 126, 137, 143, 144, 155, 182, 224, 227, 262, 279, 297, 316, 319, 362, 431.

Thirteen to seventeen inches high.—Nos. 1, 25, 26, 27, 80, 102, 116, 133, 184, 185, 190, 277, 296, 299, 372, 383–394 inclusive, 423, 428, 429 ; 28, 29, 30, 105. 113, 117, 118, 119, 127, 128, 129, 134, 175, 183, 187, 188, 189, 225, 269, 270, 314, 317, 318, 368, 371, 427, 430 ; 82, 85, 101, 103, 104, 106–112 inclusive, 114, 115, 120, 124, 139, 145, 186, 238, 242, 274, 306, 310, 320–331 inclusive, 355, 369, 417 418, 419, 421, 422 ; 3, 38, 123, 125, 240, 267, 278, 280, 359, 420, 432 ; 4, 5, 6, 62, 179,

Eighteen to twenty-three inches high.—Nos. 14. 39, 50, 52, 53, 55, 99, 136, 138, 146, 243, 252, 257, 271, 307, 311, 433, 441, 444 ; 32, 87, 135, 205, 434 ; 7, 8, 33, 36, 60, 61, 100, 140, 147, 178, 236, 239, 263, 264, 295, 303, 309, 376, 377, 442, 443, 447, 450 ; 45, 231. 235, 308, 435, 440, 449 ; 40, 56, 63, 68, 132, 232, 248, 309, 426, 437, 445 ; 172, 249, 254, 256, 258, 259, 438, 448, 451, 452, 453, 454, 455–459 inclusive.

Twenty-four to thirty inches high.—Nos. 11, 34, 37, 42, 46, 51, 59, 69, 131, 253, 255, 260, 261, 265, 300, 370, 374, 436, 439 ; 67, 171, 237, 251 ; 35, 47, 66, 122, 250, 275, 276, 305, 416 ; 173, 313, 375 ; 23, 71, 176 ; 96, 121, 142, 191–204 inclusive, 304, 312, 354, 373.

Thirty-one to forty inches high.—Nos. 9, 10, 20, 21, 58, 64, 65, 97, 142, 177, 353 ; 15, 48, 54, 70, 73, 95, 98, 130, 166, 169, 223, 241, 244 ; 5, 6, 7.

Forty-one inches and above.—Nos. 8, 88–94 inclusive, 160–168 inclusive, 170, 180, 181, 205–217 inclusive, 221, 315, 346–352 inclusive, 378–382 inclusive, 395–416 inclusive.

Kinds desirable for borders or edging.—Nos. 18, 19, 24, 25, 74–79 inclusive, 101–119 inclusive, 159, 182–190 inclusive, 224, 225, 226, 227, 228, 233, 234, 278–287 inclusive, 334–342 inclusive, 357, 358, 367.

Good for bedders.—Nos. 7, 8, 9, 10, 11, 23, 28, 29, 32–45 inclusive, 48–53 inclusive, 60–69 inclusive, 82–87 inclusive, 99–120 inclusive, 123–129 inclusive, 133–136 inclusive, 138–158 inclusive, 176, 177, 182-204 inclusive, 222, 223, 231, 241, 242, 243, 248–271 inclusive, 278, 279, 280, 295, 296, 297, 298, 300–311 inclusive, 314, 316–331 inclusive, 334–342 inclusive, 353, 354, 355, 356, 359, 360, 363, 364, 365, 366, 370–377 inclusive, 383–394 inclusive, 418–424 inclusive, 427–431 inclusive, 440–459 inclusive.

Kinds in bloom at Ithaca after the first frost.—Nos. 1, 2, 7, 8, 20, 21, 32–39 inclusive, 43, 44, 45, 47, 49, 50, 51, 54, 55, 56, 58, 59, 61, 82–86 inclusive, 101–129 inclusive, 133, 134, 135, 136. 139, 141, 142, 143, 146–150 inclusive, 152, 153, 154, 157, 159, 174, 182, 222, 249–262 inclusive, 264, 265, 267, 269, 270, 296, 297, 298, 316–333 inclusive, 353, 354, 355, 418–431 inclusive.

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Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

The Period of Gestation in Cows.

By HENRY H. WING.

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THE PERIOD OF GESTATION IN COWS.

Since 1889, observations of the period of gestation have been regularly made on all the cows in the University herd. The herd has contained an average of about twenty cows, about two-thirds Holstein and high grade Holstein, and one-third Jersey and high grade Jersey with a few native, mixed, and cross bred cattle. Nearly all the animals were bred and raised on the farm from dams so bred and raised. So that the observations were taken from a single herd and its descendants. In all, 194 observations have been made; of these, 9 terminated in the birth of dead calves prior to 253 days of pregnancy and three more were doubtful so that the 12 have been excluded and the averages confined to the 182 births that may be considered normal. The number of days required for gestation in each of these cases, and the sex of the offspring, is shown in Table I.

TABLE I.

Period of gestation days.	Number of cows.	Number of cow calves.	Number of bull calves.	Number of twin calves.
264	1	1		
267	1	1		
268	3	1	2	
271	4	1	3	
272	1		1	
273	5	1	2	2*
274	11	4	6	1†
275	10	4	6	
276	13	4	9	
277	15	9	5	1†
278	9	3	5	1*
279	15	11	4	
280	15	10	5	
281	7	6	1	
282	10	5	5	
283	16	9	7	
284	11	2	9	
285	9	4	5	
286	8	3	5	
287	7	2	5	
288	3	2	1	
289	2	1	1	
290	1		1	
293	2	1	1	
294	2	1	1	
296	1	1		
	182	87	90	5

* Bull and cow calves.

† Two cow calves

AVERAGES OF TABLE I.

General average including twins		182 births	280 days
	Average, bull calves	90 "	280 "
	" cow calves	87 "	280 "
	" twin calves	5 "	275 "
By breed affinity (exclusive of twin births).			
Holstein and Holstein grades		97 births	280 days
	bull calves	51 "	280 "
	cow calves	46 "	280 "
Jersey and Jersey grades		56 "	279 "
	bull calves	28 "	279 "
	cow calves	28 "	279 "
Mixed and cross bred		24 "	283 "
	bull calves	11 "	284 "
	cow calves	13 "	282 "
According to the age of dam (exclusive of twin births).			
From 2-year-old cows		26 births	278 days
	bull calves	14 "	277 "
	cow calves	12 "	278 "
From 3-year-old cows		31 "	280 "
	bull calves	19 "	280 "
	cow calves	12 "	280 "
From 4-year-old cows		29 "	281 "
	bull calves	16 "	281 "
	cow calves	13 "	282 "
From cows 5-year-old and over		90 "	280 "
	bull calves	40 "	281 "
	cow calves	50 "	280 "

In this summary fractions of days have been omitted which will account for some apparent discrepances.

The statements in text books as to the period of gestation in the cow are commonly drawn from Earl Spencer's tables* which are based on the period of gestation of 764 cows of the "Durham or improved short-horned breed" observed for several years previous to 1839. The averages are as follows:

General average, 764 births	283 days.
bull calves, 401 births	284 "
cow calves, 340 births	283 "
twin calves, 23 births	277 "

In commenting on the table Earl Spencer says: "It will be seen that the shortest period of gestation, when a live calf was produced, was 220 days, and the longest 313 days; but I have not been able to rear any calf produced at any earlier period than 242 days. Any calf produced at an earlier period than 260 days must be considered decidedly premature; and any period of gestation exceeding 300 days must also be considered irregular; but in this latter case the health of the produce is not affected."

---

*On the Gestation of Cows, by the Right Hon. Earl Spencer, Jour. Royal, Agr. Society, I, 1840, p. 165.

While the number of observations which we have been able to make is not enough to allow of extensive generalizations, still it may be permissible to generalize somewhat till more extensive observations shall make possible more definite conclusions.

The average period of gestation with us has been almost exactly 280 days and is the same regardless of the sex of the offspring, which is contrary to the general belief, perhaps based on Earl Spencer's tables, that the male calf is carried from one to three days longer than the female. The shortest period we have observed is 264 days and the longest 296. This as would be expected from the much smaller number of observations is a much narrower range than was observed by Earl Spencer.

While as has been said the average period of gestation is almost exactly two hundred and eighty days, a close study of Table I will show that the great majority of births occur from the 274th to the 287th day inclusive and that within this period the births are fairly equally distributed. It would thus appear that there is a period of about two weeks on any day of which the chances are approximately equal that the gestation will end. The great practical importance of a knowledge of the period of gestation is of course in knowing when the gestation is likely to terminate so that the animal may receive the care and attention that is necessary. In studying the records of individual animals in this respect we have noticed that in very many cases there seems to be a characteristic peculiarity of the animal as to the period of gestation. We have noticed in some animals that the period of gestation is uniformly either considerably longer or considerably shorter than the average. In others that the same rule holds true except as to a single birth which may depart widely from all the other births of the same animal. While with still other animals the period of gestation varies very widely with the different births. This has seemed of so much interest that we have given below the details of the gestation of twenty-one cows that have produced four or more calves, arranged in groups according to the above characteristics.

TABLE II.

A. Cows whose period of gestation has been fairly uniform and usually markedly longer or shorter than the average.

		Sex of calf.	Period of gestation.
Mollie, born Sept. 25, 1889:			
	Sept. 25, 1891,	cow	——
	Sept. 10, 1892,	bull	285
	Sept. 3, 1893,	cow	281
	Oct. 14, 1894,	bull	283
	Sept. 11, 1895,	cow	285
	Oct. 24, 1896,	bull	284
	Sept. 14, 1897,	cow	280
	Sept. 9, 1898,	cow	294
			Avg. 285
Emma, born Sept. 20, 1890:			
	Feb. 2, 1893,	cow	284
	May 5, 1894,	bull	280
	Aug. 25, 1895,	cow	279
	Sept. 9, 1896,	bull	282
	Aug. 22, 1897,	bull	279
	Sept. 7, 1898,	cow	282
			Avg. 281
Pearl, born Sept. 10, 1888:			
	Aug. 5, 1890,	cow	267
	Sept. 1, 1891,	cow	274
	Sept. 16, 1892,	bull	279
	Sept. 3, 1893,	bull	280
	Aug. 21, 1894,	bull and cow	——
	May 11, 1896,	bull	278
	Mch. 25, 1897,	cow	278
			Avg. 276
Dora, born Sept. 1, 1891:			
	Aug. 27, 1893,	bull	268
	Aug. 30, 1894,	cow	278
	Sept. 5, 1895,	bull	274
	Nov. 20, 1896,	cow	274
	Dec. 25, 1897,	bull	273
	Dec. 2, 1898,	bull	275
			Avg. 274

B. Cows similar to group *A* except that one or two gestations have been markedly longer or shorter than the others. The divergent gestation is printed in italics.

		Sex of calf.	Period of gestation.
***Julia*, *born Oct. 6, 1891* :**			
	Sept. 18, 1893,	bull	283
	Oct. 24, 1894,	bull	284
	Oct. 12, 1895,	cow	293
	Sept 10, 1896,	*cow*	*280*
	Oct. 10, 1897,	bull	288
	Sept. 24, 1898,	bull	286
			Avg. 286
***Belva 2d*, *born Oct. 4, 1893* :**			
	Sept. 18, 1895,	*cow*	*277*
	Sept. 22, 1896,	bull	290
	Sept. 9, 1897,	bull	283
	Oct. 17, 1898,	bull	294
			Avg. 286
***Cherry*, *born Sept. 21, 1893* :**			
	Sept. 18, 1895,	bull	283
	Sept. 18, 1896,	bull	284
	Oct. 28, 1897,	bull	287
	Dec. 12, 1898,	*cow*	*279*
			Avg. 283
***Freddie*, *born Aug. 28, 1885* :**			
	1887,	——	——
	1888,	——	——
	Sept. 4, 1889,	bull	287
	Sept. 18, 1890,	cow	287
	Oct. 6, 1891,	cow	288
	Sept. 15, 1892,	cow	283
	Aug. 23, 1893,	*bull and cow*	*273*
	Aug. 28, 1894,	*bull*	*274*
			Avg. 282
***Pet*, *born Sept. 14, 1885* :**			
	1887,	——	——
	1888,	——	——
	Aug. 29, 1889,	bull	285
	Sept. 20, 1890,	cow	283
	Mch. 2, 1892,	cow	——
	Apr. 9, 1893,	*bull and cow*	*273*
	Apr. 11, 1894,	cow	285
	June 15, 1895,	cow	283
			Avg. 282

Beauty, age unknown :

Feb. 14, 1890,	bull	276
Feb. 11, 1891,	cow	277
Jan. 15, 1892,	bull	276
Nov. 9, 1892,	bull	278
Sept. 21, 1893,	cow	279
Sept. 11, 1894,	*bull*	*287*
Sept. 22, 1895.	cow	280
		Avg. 279

Gazelle, born Jan. 25, 1888 :

Sept. 6, 1890,	bull	275
Feb. 8, 1892,	cow	278
Dec. 1, 1892,	cow	275
Oct. 25, 1893,	bull	277
Sept. 24, 1894,	*bull*	*286*
Aug. 27, 1895,	cow	279
		Avg. 278

Cora, age unknown :

Mch. 26, 1890,	cow	277
Feb. 11, 1891,	bull	277
Jan. 16, 1892,	cow	275
Dec. 31, 1892,	bull	279
Dec. 15, 1893,	*bull*	*283*
		Avg. 278

Daisy, born March 26, 1890 :

Sept. 20, 1891,	cow	—
Sept. 22, 1892,	bull	274
Sept. 13, 1893,	bull	275
Sept. 12, 1894,	cow	277
Sept. 21, 1895,	*cow*	*282*
		Avg. 277

Glista 4th, born Oct. 9, 1892 :

Oct. 17, 1894,	*bull*	*280*
Sept. 2, 1895,	bull	272
Sept. 12, 1896,	bull	274
Sept. 28, 1897,	bull	276
Sept. 8, 1898,	cow	277
		Avg. 276

Bertha, born Aug. 15, 1888 :

Oct. 17, 1890,	bull	278
Sept. 16, 1891,	cow	268
Oct. 7, 1892,	bull	275
Sept. 30, 1893,	bull	274
Sept. 17, 1894,	*cow*	*282*
Aug. 30, 1895,	bull	276
		Avg. 275

C. Cows whose period of gestation has been variable.

	Sex of calf.	Period of gestation.
Garnet Valentine, born Sept. 2, 1891:		
Aug. 18, 1893,	cow	abortion
Aug. 30, 1894,	bull	273
Aug. 31, 1895,	cow	285
Aug. 29, 1896,	cow	276
Sept. 13, 1897,	cow	285
		Avg. 280
Sadie, born March 2, 1892:		
Mch. 21, 1894,	bull	280
Mch. 10, 1895,	bull	287
May 1, 1896,	cow and cow	274
June 25, 1897,	cow	280
		Avg. 280
May 2d, born Nov. 20, 1892:		
Sept. 16, 1894,	cow	271
Sept. 13, 1895,	bull	279
Sept. 28, 1896,	cow	279
Sept. 11, 1897,	bull	283
Dec. 18, 1898,	bull	284
		Avg. 279
Ruby, born Sept. 16, 1888:		
Sept. 6, 1890,	cow	279
Sept. 11, 1891,	cow	280
Nov. 14, 1892,	cow and cow	277
Feb. 22, 1894,	cow	283
Jan. 31, 1895,	cow	286
Dec. 24, 1895,	bull	283
Dec. 26, 1896,	cow	281
May 26, 1898,	bull	282
		Avg. 281
Gem Valentine, born Jan. 4, 1889:		
Jan. 10, 1891,	bull	268
Mch. 21, 1892,	cow	282
Jan. 26, 1893,	cow	274
Nov. 24, 1893,	bull	276
Oct. 20, 1894,	bull	284
Sept. 1, 1895,	cow	283
Sept. 5, 1896,	bull	278
Oct. 16, 1897,	bull	287
Dec. 11, 1898,	bull	285
		Avg. 280

Belva, born Sept. 4, 1886:		
1888,	——	——
Sept. 8, 1889,	bull	275
Aug. 14, 1890,	cow	280
Oct. 2, 1891,	cow	286
Sept. 26, 1892,	bull	278
Oct. 4, 1893,	cow	279
Sept. 16, 1894,	cow	284
		Avg. 280

It will be seen that the larger number of cows fall into the second group, i. e., those whose period of gestation is uniform with a single exception. Taking group *A* and group *B* together, it would seem that in the great majority of cases after a cow has had one or two calves it ought to be possible to predicate her period of gestation quite closely. It has already been shown that the gestations where twins have been carried, average quite a good deal shorter than when but one calf is born. This is true not only of our own observations but of Earl Spencer's as well. The difference is still more marked if the twin gestations are compared with the other gestations of the same animal as is shown in detail below.

TABLE III.

Comparison of Twin Gestations with other gestations of same cow.

	Sex of calf.	Days of gestation.
Freddie, born Aug. 28, 1885:		
Sept. 4, 1889,	bull	287
Sept. 18, 1890,	cow	287
Oct. 6, 1891,	cow	288
Sept. 15, 1892,	cow	283
Aug. 23, 1893,	*bull and cow*	*273*
Aug. 28, 1894,	bull	274
		Avg. 282
Pet, born Sept. 14, 1885:		
Aug. 29, 1889,	bull	285
Sept. 20, 1890,	cow	283
Mch. 2, 1892,	cow	——
April 9, 1893,	*bull and cow*	*273*
April 12, 1894,	cow	285
June 15, 1895,	cow	283
		Avg. 282

Ruby, born Sept. 16, 1888:

Sept. 6, 1890,	cow	279
Sept. 11, 1891,	cow	280
Nov. 14, 1892,	*cow and cow*	*277*
Feb. 22, 1894,	cow	283
Jan. 31, 1895,	cow	286
Dec. 24, 1895,	bull	283
Dec. 26, 1896,	cow	281
May 26, 1898,	bull	282
		Avg. 281

Sadie, born March 2, 1892:

Mch. 21, 1894,	bull	280
Mch. 10, 1895,	bull	287
May 1, 1896,	*cow and cow*	*274*
June 25, 1897,	cow	280
		Avg. 280

Glista Netherland, born Nov. 21, 1892:

Oct. 21, 1895,	bull	285
May 10, 1897,	cow	280
Sept. 1, 1898,	*bull and cow*	*278*
		Avg. 281

SUMMARY OF TABLE III.

	Average of all gestations days.	Average of all except twin gestation days.	Twin gestation days.
Freddie	282	284	273
Pet	282	284	273
Ruby	281	282	277
Sadie	280	282	274
Glista Netherland	281	282	278
Average	281	283	275

SUMMARY.

Of 182 births the average period of gestation was almost exactly 280 days.

The shortest period was 264 days; the longest 296 days.

Approximately equal numbers of births occurred on each day from the 274th to the 287th inclusive.

The period of gestation was the same for male and female calves.

The period of gestation where twins were born was five days less than the general average and eight days less than the average of the single births of the same cows.

Many cows show a well marked individual characteristic as to period of the gestation which may be several days longer or shorter than the average.

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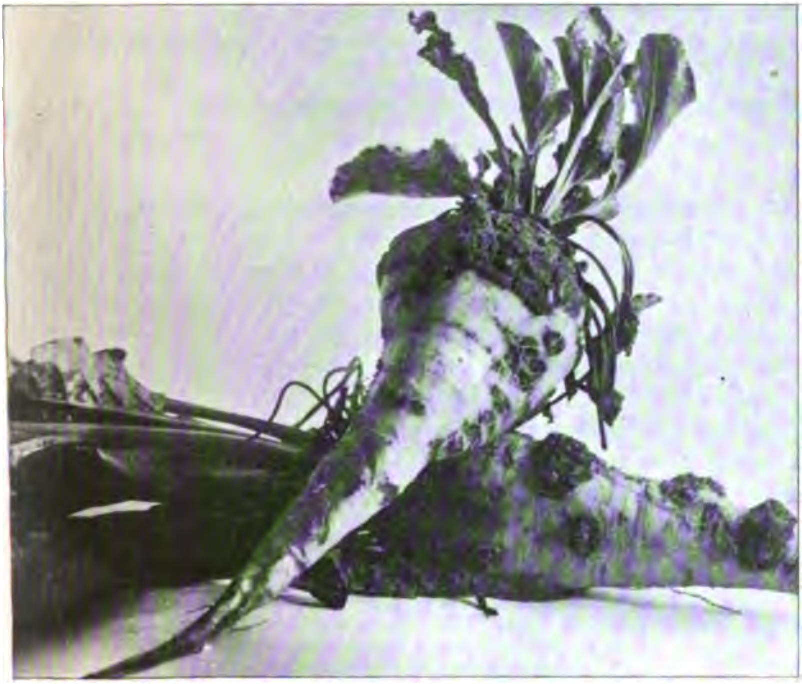
Bulletin 163. **February, 1899.**
Cornell University Agricultural Experiment Station.
ITHACA, N. Y.

BOTANICAL DIVISION.

THREE IMPORTANT FUNGOUS DISEASES OF THE SUGAR BEET.



By B. M. DUGGAR.

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CORNELL UNIVERSITY, ITHACA, N. Y., Feb. 3d, 1899.

THE HONORABLE COMMISSIONERS OF AGRICULTURE,

ALBANY, N. Y.

Sir:—The great awakening in the production of sugar beets naturally leads to a careful study of the diseases which effect them and which may, in many cases, seriously reduce the yield, therefore, it has been thought wise to make somewhat extended studies of some of the diseases of the sugar beet observed during the past season.

Mr. B. M. Duggar has made most careful investigations and studies of three diseases which are more or less prevalent. An attempt has been made to confine the work largely to those diseases which have proven to be of economic importance in this state. The "root rot" is a new disease in the Eastern states, but in the few localities where it was present during the past year it showed its possibilities for harm, and remedial measures should be at hand. This fungous is of special interest since it may cause diseases of other plants. The leaf spot of beets is ubiquitous in its occurrence, and in many localities it caused severe loss during the past season. The work here presented is the result of work in laboratory and field. The abundance and distribution of the diseases have received special attention in the field studies.

I. P. ROBERTS,

Director.

THREE IMPORTANT FUNGOUS DISEASES OF THE SUGAR BEET.

I. Root-Rot of Beets (*Rhizoctonia Betæ* Kühn.).
  - *a. Occurrence of the Disease.*
  - *b. Appearance of the Affected Plants.*
  - *c. The Cause of the Beet Root-Rot.*
  - *d. Special Characters of the Fungus.*
  - *e. The Beet Root-Rot Fungus as a Cause of Other Types of Plant Diseases.*
  - *f. Remedies.*

II. Leaf Spot of the Beet (*Cercospora beticola* Sacc.)
  - *a. General Account.*
  - *b. Characters of the Fungus.*
  - *c. Remedies.*

III. Beet Scab (*Oospora scabies* Thaxter.)
  - *a. Appearance of the Disease.*
  - *b. The Cause of the Disease and its Prevention.*

IV. Some References to the Literature of Beet Diseases.

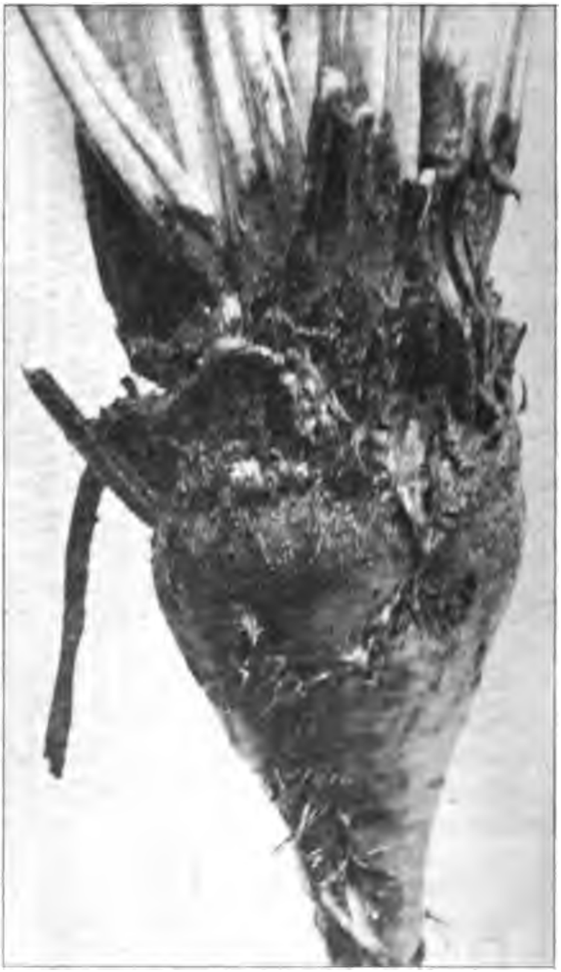
THREE IMPORTANT FUNGOUS DISEASES OF THE SUGAR BEET.

Many diseases of the sugar beet have been reported in the different countries where this crop is grown, and this is especially true of the old world, where the culture of sugar beets has formed an important industry throughout many years. Already there are three diseases in this state which should be well known to those interested in beet culture. When other diseases appear abundantly, they will also receive merited attention. The widespread distribution of beet culture during the past few years is necessarily attended by a greater distribution of the diseases. It is well at the start to know what these troubles are, and to know the methods of prevention. The losses from plant diseases are often as great, or greater, than losses due to neglect of the proper methods of culture; and as long as we must grow varieties susceptible to fungous diseases, the grower should prepare to combat these disease attacks just as efficiently as he is equipped to fulfil other necessary cultural requirements.

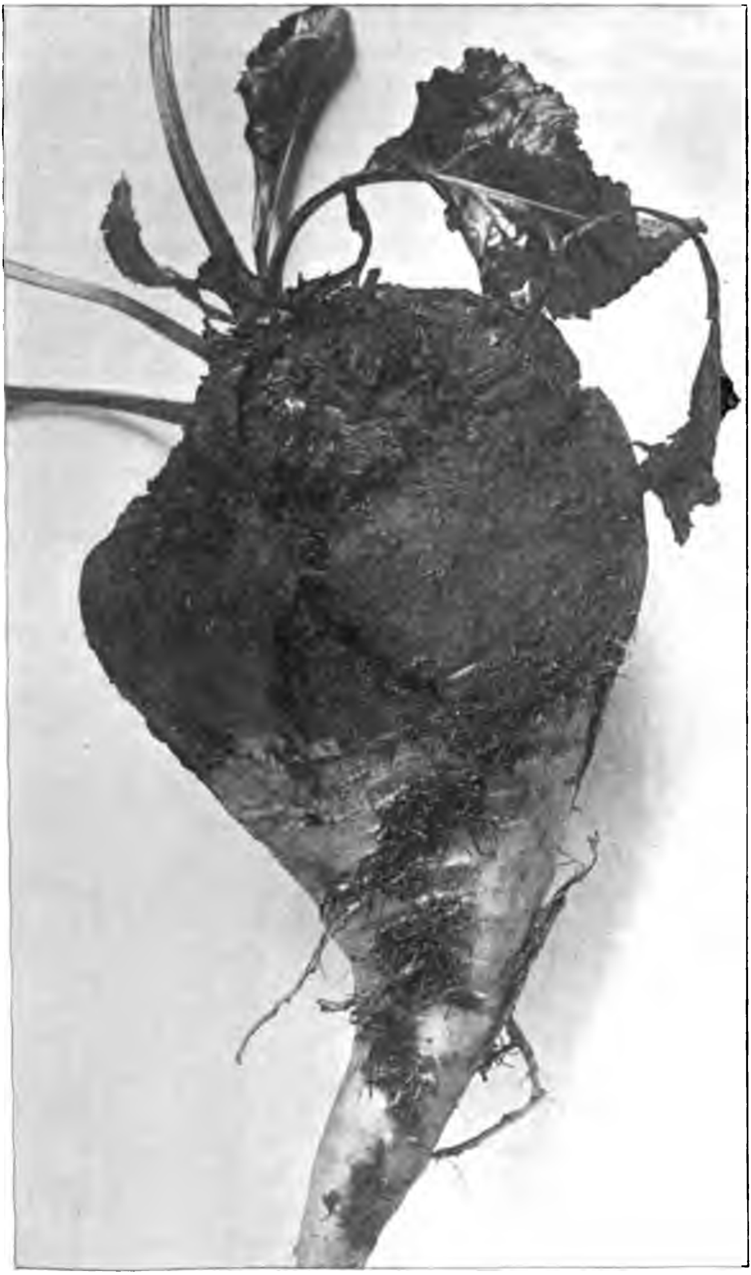
I. ROOT-ROT OF BEETS (*Rhizoctonia Betæ* Kühn.)

a. Occurrence of the Disease.

Beet root-rot was first brought to my attention as a disease of small extent in the vicinity of Binghamton. A few days afterwards it was found abundantly at Cattatonk, N. Y. A visit to the latter place on Aug. 12 demonstrated that the disease was a matter of considerable practical importance. An examination of a three-acre field on the premises of Philip Caple convinced me that probably one-third of the beets in this field were affected, and it was then too late to attempt any remedial measures with this root-rot. Fortunately, some change in the conditions soon checked it, and my notes represent the final effect of the disease. A careful study of the affected field showed one point of peculiar interest. In certain areas the chipped tan-bark of an old tannery had been thickly spread on the land, and in such areas there was not the slightest indication of diseased beets, The tannery product was quite dry; and I attributed the absence of the disease to the lessened water content of the upper layers of the soil, which assumption would be in accordance with the results of some experiments to be detailed later. Again, in a part of the field where coal ashes had been heavily applied, there was a noticeable diminution in the amount of the disease. This disease was afterwards reported from several places in the state, although it has not yet proved a common disease in New York. As mentioned later, what is probably the same disease was reported in Iowa in 1891, and it may have been



49.—*An early stage of the attack of Beet Root-Rot. The basal parts of the leaves are blackened.*



50.—*A late stage of Beet Root-Rot, showing the cracking and rotting of the root.*

observed in one or two other sections of the country. It may be the same trouble that has several times been very destructive to the sugar beet industry in Germany. Again, as subsequently noted, this beet root-rot is caused by the same fungus which causes a stem rot of carnations; and probably by the same fungus which produces some damping off diseases, so that we may predict that it has a wide distribution even at the present time.

b. Appearance of Affected Plants.

Under favorable conditions for its spread, this beet root-rot generally secures its first foothold at the bases of the leaves. These parts are moist with the slightest rain or dew, and inoculation experiments show that in those regions the disease "takes" very readily. The first evidence of the attack is manifest in the blackening of these leaf bases, the outer leaves first, so that the stalks soon become unable longer to support the blades, and the leaves may lie prostrate on the ground. The leaves do not, however, lose their green color very readily. Figure 49 shows this blackening of the leaf bases, before any injury is manifest in the other parts.

The disease soon works into the crown and root proper, causing the infested parts to turn brown. With further spread of the fungus in the root region, cracks appear, as shown in figure 50. If the conditions continue to favor the disease, in time the whole top rots away, and the beet gradually disappears. Cold weather or dry conditions may so retard the disease that plants only slightly affected may recover entirely. Ordinarily the trouble was scattered throughout the entire field affected, but numerous small areas indicate that the fungus passes rapidly from plant to plant in the row, spreading radially.

Even when the bases of the leaves alone are affected, upon careful examination one will find that there are to be seen the brown mycelial threads of the fungus growing over the surface. After the root has become affected, a considerable weft of the fungus will be evident in the cracks. A diseased beet sliced lengthwise and placed in a moist chamber yields in a day or two a luxuriant growth of the mould-like hyphæ. From this outgrowth of mycelium it is very easy to secure a pure culture of the fungus. Acidulated bean pods, or bean stems, as mentioned by Professor Geo. F. Atkinson, in his study of the sterile damping off fungus,* are excellent for this purpose. The fungus prefers an acid substance, while the ordinary bacteria of decay are shut out by such acidity. One drop of 50 per cent lactic acid to each test tube with the usual amount of medium is sufficient for best results.

If the beets are much rotted, one may find, even in the field, that the surface of roots in moist conditions is covered with a short, tuft-like growth of the fungus. I have not found that the blackened, crust-like, or more or less rounded, compact masses of the mycelium, called sclerotia, ever occur on beets in the field.

In this connection it may be well to state that all necessary cultures were made both from affected parts, and from the adjacent white meat of the beet, to determine the part that bacteria or other fungi might play in the etiology of the disease ; but no other parasitic organism was found. As Pammel has stated, bacteria are probably much concerned in the final rotting of the beet.

c. The Cause of the Beet Root-Rot.

The constant association of the brown fungus *Rhizoctonia* with the cracking and rotting of beets in the field was not taken as final evidence that this fungus caused the trouble, and although late in the season, a few experiments were undertaken to determine the degree of parasitism of the fungus, and the conditions under which it acted.

Experiment 1. In a short row of twenty-four half-grown beets eight were inoculated on Aug. 13. The inoculations were made by placing among the crown leaves fresh pieces of beet on which this fungus alone had been growing for a short time. The whole row was mulched with straw. The weather was wet for a few days only, but afterwards quite dry. On Sept. 2 eighteen beets in this row were affected by the rot.

Experiment 2. Six beets or clusters of beets were inoculated as in experiment 1, but over each inoculated area was placed a large bell glass. On Sept. 2 all of the inoculated plants were diseased, but the trouble had not spread from the bell glasses.

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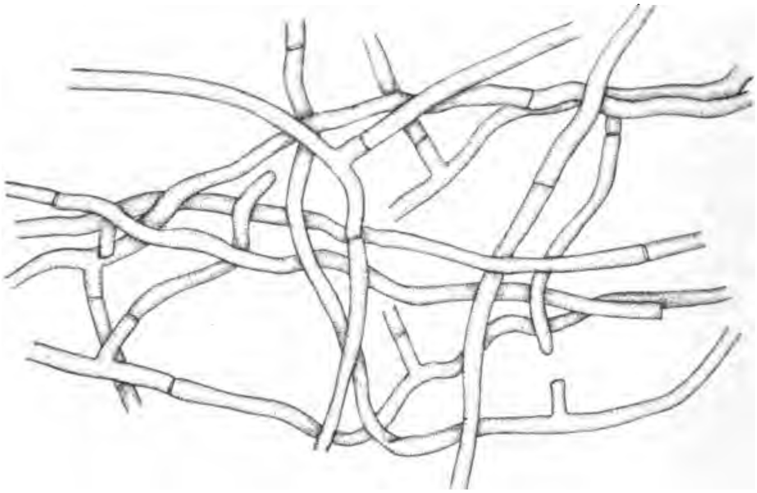
* Bulletin 94, Cornell Univ. Agl. Exp. Station, 1895.

Experiment 3. Twelve beets as above were inoculated, but with no provision for retaining moisture. On Sept. 2 nine of the inoculated plants were affected.

Experiment 4. Twelve beets were inoculated with a mixture of several bacterial forms isolated from diseased tissues and from parts of the beet immediately below diseased areas. These beets remained healthy throughout the experiment.



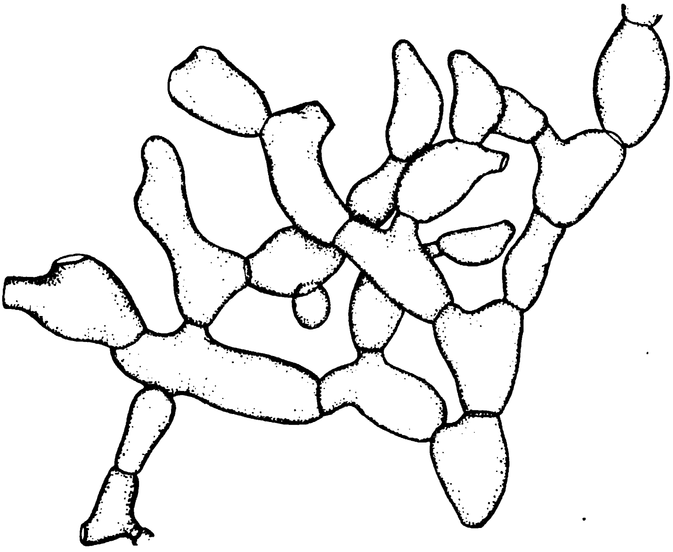
51.—*The brown hyphæ which invest the cracks on diseased beets.*

Alternating with the rows experimented upon were check rows, all of the beets in which remained perfectly free from root-rot troubles.

These experiments indicated that the fungus *Rhizoctonia* readily produces root-rot when the conditions are favorable, and that moist conditions are essential for the spread of the disease from plant to plant. Later experiments with pure cultures of the fungus growing on bean pods were used to inoculate seedling beets, and with such plants a damping off effect was produced.

d. Special Characters of the Fungus.

The morphological characters of the fungus may well be studied both from the mycelium found on the diseased beet, and from the growth in pure cultures, secured as above mentioned. In pure cultures on bean pods and on slices of sugar beet the fungus grows vigorously, and a loose mycelium first appears. However the fungus may be grown, it shows a very characteristic method of branching, which serves to identify it. In the young, vigorously growing hyphae the branches are inclined at an angle more or less acute with the direction of growth of the parent branch : and the point of union of the two is marked by a slight constriction. Invariably the branches are cut off by a septum at a distance of several micromillimeters from the parent branch. At first the mycelium is quite hyaline, and strongly vacuolate ; but with age the loose hyphae may become very light brown in color. In the older hyphae of the loose growth it is noticeable that the constrictions at the places of union of the branches are not so evident, and this is especially true of the dark colored mycelium found externally in connection with the diseased area of the beet root, as in figure 51. In the cultures the loose growth is followed by a closer tufted growth of short hyphae. On such rich media as bean pods this close growth covers almost the entire surface, and little tufts may also appear on the glass of the test tube. This growth is at first somewhat mealy in appearance, but later it becomes deep brown in color. These tufts are made up of short



52.—*The large, closely septate hyphae which make up the short tufted growth.*

hyphae much larger in diameter than those previously mentioned. They are closely septate, and constricted at the septa. Usually they branch irregularly and profusely as in figure 52, but truly dichotomous branching is often observed, and long moniliform chains of cells are not infrequent. Such tufts of hyphae are also occasionally found on beets badly rotted in the field. With age these chain-like aggregations break into hyphal elements of a single cell or of several cells attached; and most of these cells may then function as conidia, producing on germination the characteristic mycelium first mentioned. In the manner of germination these cells are peculiar. The germ tube passes out through the septum originally separating the cell from its neighbor. As soon as the germ tube has grown to an extent equal to several times the length of the parent cell, a septum invariably forms at a short distance from the latter, the proximal cell is somewhat narrowed at its exit from the hyphal cell, and the first septum decides the normal diameter of the tube. When germination takes place from an inner one of several connected cells, a peculiar phenomenon occurs. The germ tube may pass from one cell into and through its adjacent neighboring cell; and usually such cells through which germ tubes pass seem to be themselves devoid of contents, or at least they lack the vacuolate structure of the germinating cells. These characters are shown in figure 53.

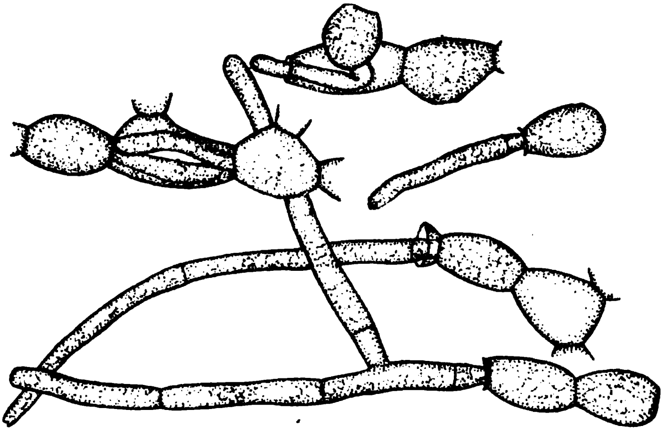
When this fungus is grown on bean stems or on other nutrient media not so rich as bean pods, crust-like sclerotial bodies are oftener formed. The sclerotia begin as a closely branched mass of filamentous hyphae, and by further growth these become so interwoven as to form a more or less compact body. Sclerotia have been more readily produced by making fresh cultures from pure cultures of the fungus which had been kept in the laboratory for a long time, the original cultures being made from damping off lettuce. In all cases, however, the hyphae and the sclerotia are very different from those of *Botrytis* and other allied fungi often causing rots and certain damping off diseases.

e. The Beet Root-Rot Fungus as a cause of Other Types of Plant Diseases.

While working with cotton diseases in Alabama in 1892, Professor Geo. F. Atkinson found that the so-called "sore shin" of seedling cotton plants is abundantly produced by sterile fungus. Some of the results of this work were published in Bulletin 41 of the Alabama Experiment Station. In his later work at this Experiment Station upon damping off fungi, the same fungus was again found to cause damping off of many seedlings, especially of lettuce, cabbage, radish, egg-plant, &c. Under the caption "Damping off by a Sterile Fungus," in Bulletin No. 94 of this

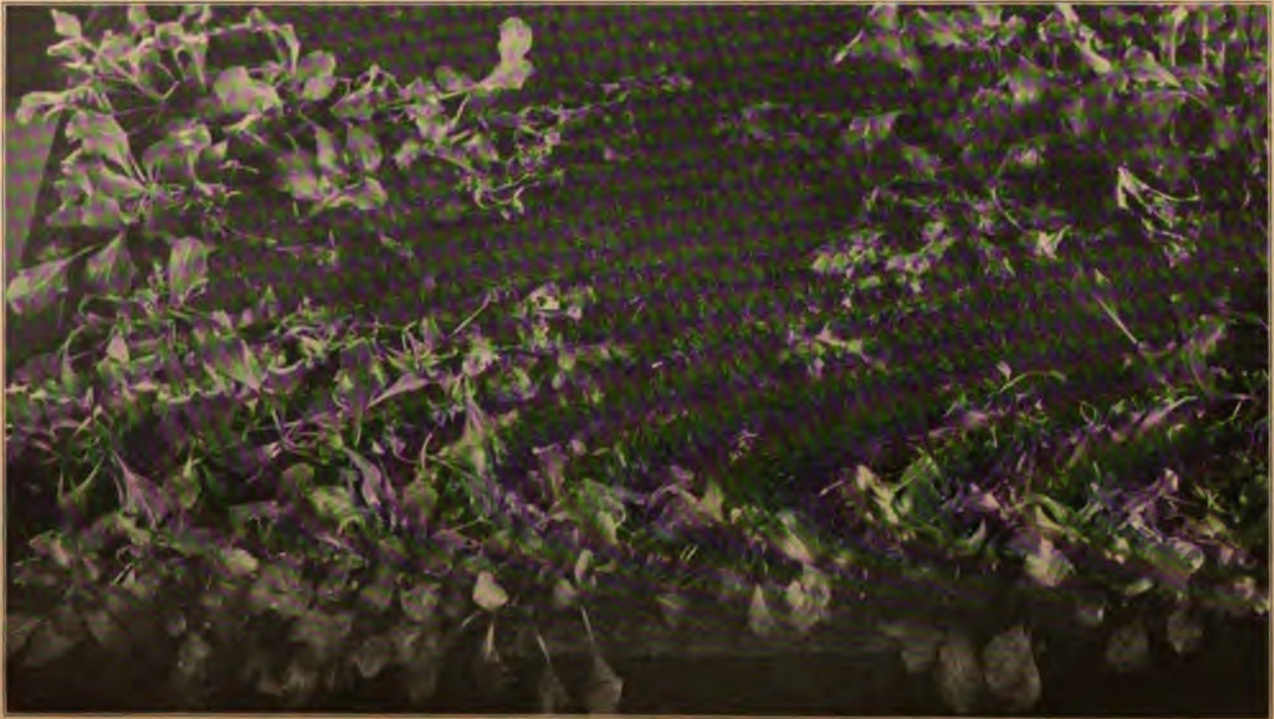
Experiment Station, the fungus was described in considerable detail.

During the past two years I have continued studies upon certain damping off fungi, and this sterile fungus has often been found as the cause of damping off in seedling lettuce, beans, and cucumbers, and occasionally in many other seedlings. That the fungus referred to is the cause of these troubles has been proved in the case of the lettuce and radishes by inoculation with pure culture. Seedlings affected by this fungus show the usual characteristics of damping off. The plants first show signs of weakness near the surface of the ground, the water-soaked tissues of this region are soon unable to support the plant, and it may fall prostrate on the surface of the ground, the fungus soon invading all parts. Among lettuce seedlings, especially, this fungus spreads rapidly from plant to plant ; and a box of seedlings may have the appearance of being wilted down, as in figure 54. Damping off diseases of seedlings which have been growing normally should not be confused with the simple wilting of seedlings in dry soil, or to the wilting due to the transfer of seedlings from a warm soil to a cold soil, etc.



53.—*Germinating cells of the Root-rot fungus.*

In the winter of 1898 I received from a correspondent radishes of marketable size which showed a soft rot of the crown, or ulcerated areas in the region of the crown, as shown in figure 55.



54.—*A box of lettuce seedlings damping off by the sterile fungus.*

The leaves were usually unaffected until large portions of the fleshy roots had rotted. Cultures from diseased parts again yielded a fungus with structural characters exactly similar to those of the sore shin and damping off fungus.

When the beet fungus was first isolated and studied I was surprised to find a fungus agreeing in structural details with the one causing damping off, radish rot, &c. The growth characters of the fungi in pure culture were also practically the same, and experiments were soon instituted to determine if, under any circumstances, the beet fungus could cause damping-off. In the first experiments to determine this point, lettuce and radish seedlings were used. Small pieces of beet on which the beet fungus was growing profusely were put at definitely marked places in a large box of lettuce seedlings on Sept. 26. Similar inoculations were made in a box of radish seedlings, and in both instances checks were observed. On the second day, at every point where the the beet *Rhizoctonia* had been introduced a few lettuce seedlings were diseased, and in five days a considerable area about each piece had damped off. With the radish seedlings damping off was very slow, and no large number of seedlings succumbed ; but in seven days a few plants were affected at about one-half of the inoculation centers. Subsequent work seems to indicate that the fungus from beets does not cause damping off of

55.—*Radishes affected with soft rot of the crown.*

a very violent kind, but that it may cause damping off of lettuce, cotton, and some other plants to a limited extent. Owing to the similarity in morphological characters of these forms of *Rhizoctonia* from the sources mentioned, and with the experimental evidence available, it seemed at first that these forms were exactly identical. Further evidence may indicate that we must recognize differences which are at least racial, not permitting of the ready transfer in a single generation of the beet fungus to seedlings of other plants, or vice versa.*

Mr. F. C. Stewart, of the Geneva Station, is at work upon a stem rot of carnations and the fungus causing this disease of carnations is identical in all morphological characters with the *Rhizoctonia* of beet root-rot. Experimental proof has also been established showing that the two diseases are due to the same organism ; and this evidence is detailed in the paper mentioned below.

From the work of Kühn and Pammel it is quite evident that the beet fungus should be referred to *Rhizoctonia Betæ* Kühn ; but at this time it is undesirable to enter into any discussion concerning the proper limitation of species in this genus which has been variously treated by Tulsane†, Comes‡, and others.

f. Remedies.

The use of lime as a possible preventive for certain rhizoctonial diseases has been recommended. The use of an alkali as a preventive might be logically suggested knowing the avidity with which the fungus grows on acidulated nutrient media. The failure of the *Rhizoctonia* to cause trouble in those parts of the field where coal ashes had been used abundantly again suggests the same remedy. Furthermore, Mr. F. C. Stewart has determined that a small amount of alkalinity is fatal

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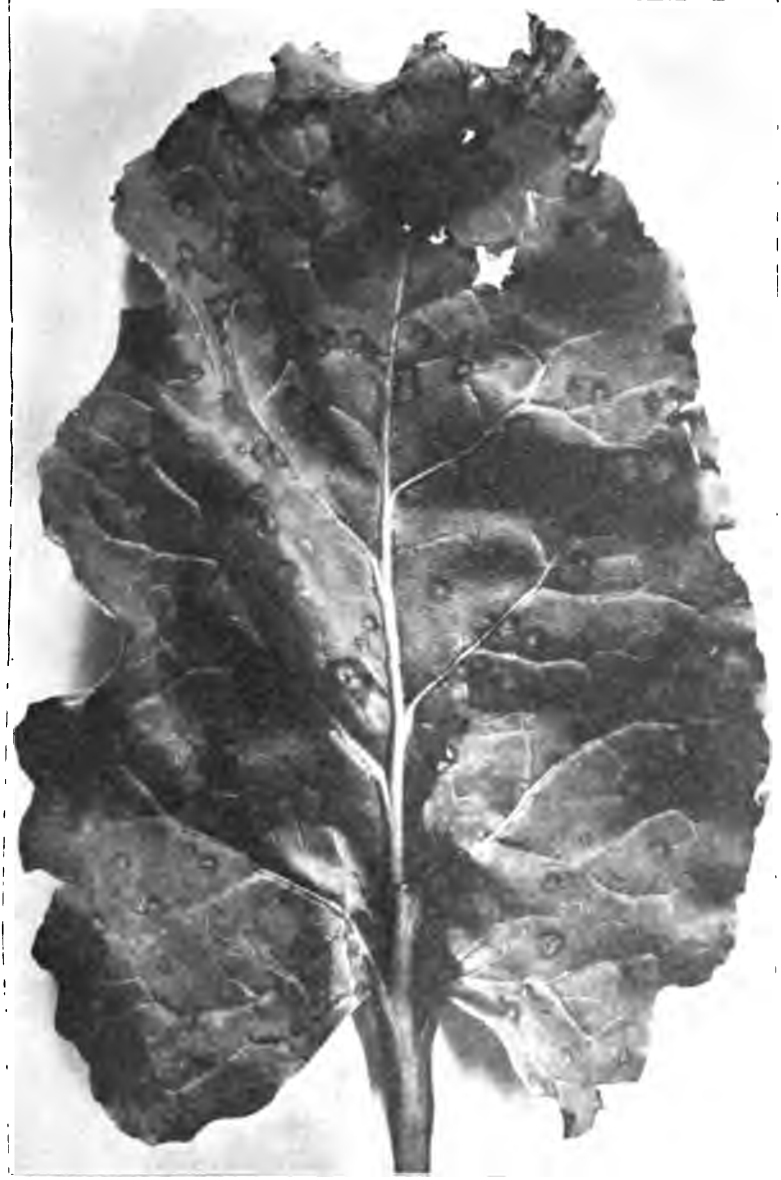
* Further details bearing upon the similarity of these forms of *Rhizoctonia* will be found in a paper presented before the Society of Vegetable Morphology and Physiology, Dec., 1898, entitled "Different Types of Plant Diseases Due to a Common *Rhizoctonia*," by B. M. Duggar and F. C. Stewart. This paper will soon be published in the Botanical Gazette.

† Tulasne, L. R. & C. Fungi Hypogæi, pp. 188—195.

‡ Comes, O. Crittogamia Agraria.



56.—*A beet leaf showing the early stages of injury due to the leaf spot fungus.* (*Photographed by Prof. Geo. F. Atkinson.*)

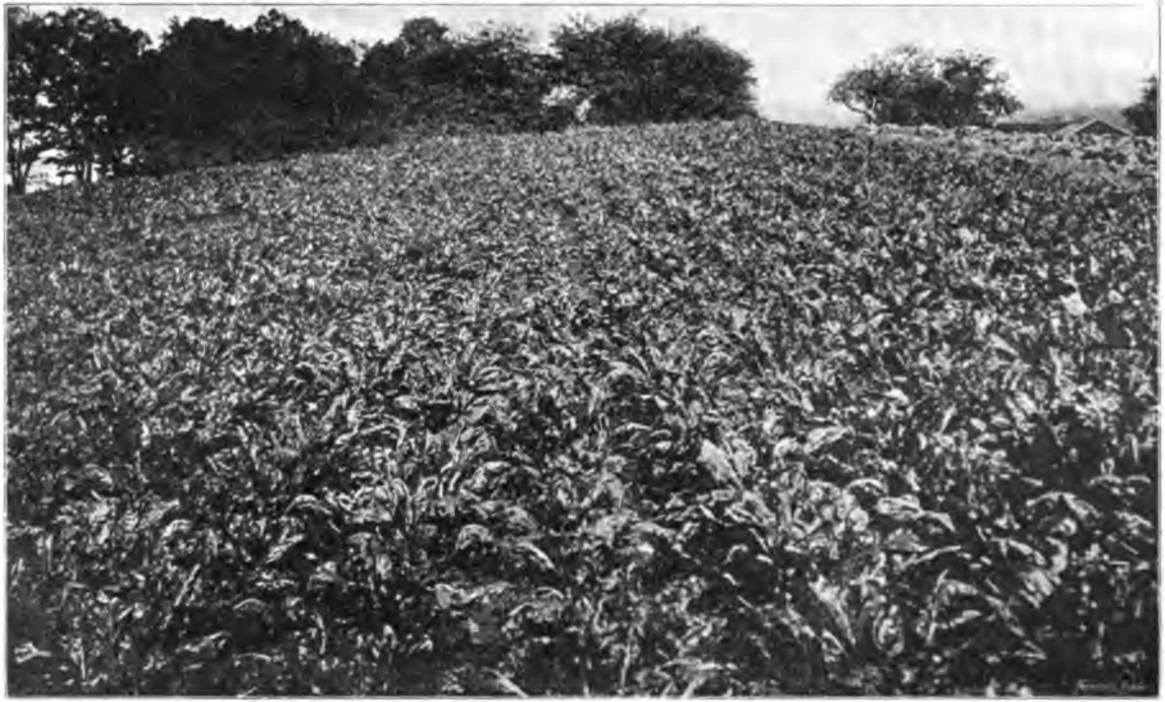
to the growth of the *Rhizoctonia* of carnations in cultures. In general it seems that the soils of the State are usually in need of liming, and where this beet disease appears it would be very well to make an application of lime. Sixty to seventy bushels of air-slaked lime per acre would be a cheap and effective means of securing the desired alkalinity. It would be preferable to make this application in the autumn, or at least before the ground is turned, so that the lime would be well distributed.

II. LEAF SPOT OF THE BEET (*Cercospora beticola* Sacc.).

a. General Account.

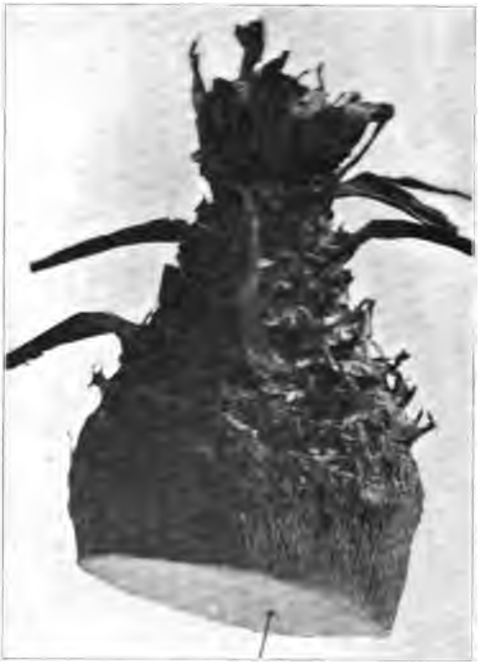
The above disease is one of very wide distribution. It has long been known both in this country and in Europe, and it probably occurs in all regions where beets are grown even to a limited extent. It is a well known disease of the red garden beet, but many of the garden varieties are so resistant that the disease is not there a matter of great concern. My observations in this State indicate that it is much more injurious to sugar beets, than to the red varieties, and much damage was done by it during the past year. For this reason it needs to be brought to the special attention of those interested in the culture of sugar beets.

The name well denotes the appearance of the disease, at least in the early stages. It begins as small brown spots with a reddish purple margin, these spots being scattered irregularly over the leaf, as in figure 56. The spots become ashen gray at the centers, with the border as before; and they may become so numerous as to cover a large portion of the surface of the leaf before there is any general discoloration of the blade. In time, however, the blade shows a parched appearance, begins to blacken gradually from the distal portions towards the stalk, and finally the whole leaf is black and crisp. As soon as the leaves begin to appear parched and dry, they stand more nearly upright on the crown, and a whole field badly affected with this disease makes a very characteristic appearance, as shown in figure 57. The individual blades that are badly affected are somewhat curled or rolled, and even this is slightly evident in the photograph.



57.—*A field of beets near Owego badly injured by the leaf-spot fungus; the curled and upright condition of the leaves indicate the trouble.*

The outer or older leaves are of course first affected, and after the leaf stalks wilt these leaves are shed. In the meantime the plant is endeavoring to supply this deficiency of leaves by continuing to develop new ones from the center, or from the bud. In consequence of this, the crown becomes considerably elongated, as in figure 58. During the past summer several fields of beets were observed in which the majority of the plants showed crowns thus elongated. If this is very marked, the roots are abnormally small, and much of the energy of the plant is evidently directed to saving itself. Even where the leaves are much less injured, it is undoubtedly a matter of economy to resort to preventive measures.



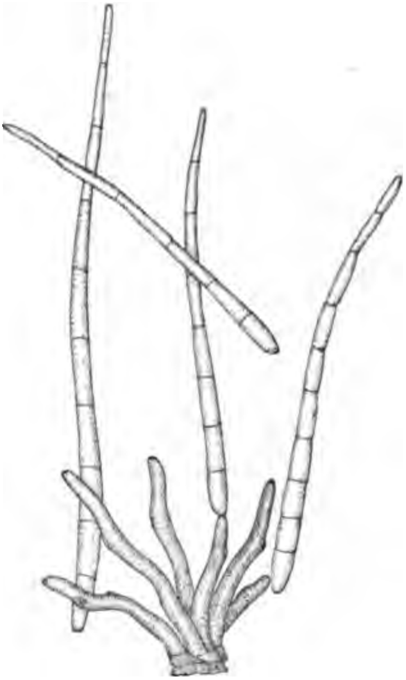
58.—*Prolonged crown of a beet which has been affected by the leaf-spot fungus.*

During the present season this disease has been especially abundant in the valleys along the streams, but there is every reason to believe that it is usually quite as abundant in the high land as in the low land. In the same field the conditions seem to make but little difference; it is found in the moist basins, and on the well-drained knolls.

Sorauer has stated that the leaf spot fungus is not confined to the leaves, that it is also to be found upon the bracts and peduncles of the flowers, and even upon the seed pods themselves. For this reason he thinks that the disease may be transmitted through the seed so as to be in readiness to affect young seedlings.

b. Characters of the Fungus.

The leaf spot of beets is caused by the fungus *Cercospora beticola* Sacc. When the spots on diseased leaves begin to look somewhat grayish in appearance, the reproductive or propagative parts of the fungus will be found abundantly. The upright blackened leaves often show this ashen appearance over the entire surface. Examining under the microscope a little of this material scraped off with the knife there will be found numerous clusters of short erect hyphae, such as are represented by the darker lower portion of figure 59. These hyphae bear the spores, or reproductive bodies, represented in the upper portion of the figure. These spores are carried about by the wind from diseased leaves to healthy leaves, and from diseased plants to healthy plants; where they fall they germinate, if the conditions are suitable; and on growing again within the tissues of the beet leaf they produce the characteristic spots.



59.—*Fertile hyphae and spores of the leaf-spot fungus.*

The fertile hyphae are about 35–55x4–5.* The conidia vary considerably in size, but are usually 75–200x3.5–4.5,* although much longer if produced in very moist conditions, or in a moist chamber. Pure cultures of the fungus may be readily secured by the ordinary method of dilution culture. The colonies show up well in the petri dishes after a growth of a few days, as shown in figure 60. The mycelium grows in a close mat, deeply olivaceous in color. The aerial growth is also oblivaceous at first, and later it is grayish-green. Transfers to sterile bean pods have given excellent growths in pure culture. Cultures of the fungus have been kept in the laboratory for two years, and during this time some attempts have been made to secure any other stages that might be connected with the *Cescospora*, but in culture no fruiting forms have been secured. In studies of some other species of *Corcospora* more or less abnormal conidia* were produced, but with this beet fungus not even conidia are developed in cultures. There is a tendency for the aerial hyphae to adhere in clusters as they grow out from the substratum, as in the upper portion of figure 61, and from these hyphae branches arise as if to bear conidia, but none are produced. In the lower portion of figure 61 is represented some of the characteristic mycelium which grows immersed, abundant swellings and irregular branching occurring. A close inspection has been made of old diseased leaves during the autumn and winter, but no fungi have yet been found which seem to suggest a perfect stage of this *Cercospora*.

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* Measurements expressed in micromillimeters.

60.—*Petri dish culture of the leaf-spot fungus on agar.*

c. Remedies.

During the past season the serious injuries due to the leaf spot were not manifest until it was deemed too late to make satisfactory experiments with the use of fungicides for its prevention. For several years, however, experiments have been conducted by Professor Halsted, at the New Jersey Experiment Station, in the treatment of this disease, and a successful remedy seems to be at hand in the well-known Bordeaux mixture. Numerous fungicides were experimented upon, but the Bordeaux mixture has proved most efficient.

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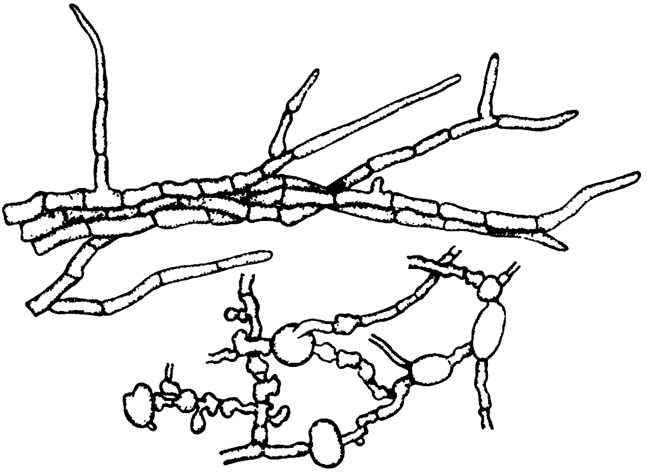
*Compare, Early Blight of Celery, Bulletin 132 of this Station.



61.—*Mycelium of Cercospora beticola as grown in pure culture.*

There is every reason to believe that by beginning the sprayings early the leaf-spot may be almost entirely prevented by the use of this fungicide. If the disease continues so disastrous as it was in certain sections during the past season, for success growers must expect to spray their beets with the same regularity as has been found necessary in growing potatoes. The standard formula for the Bordeaux mixture should be used, consisting of:—

Copper sulfate (Blue Vitriol)	6 pounds
Fresh stone lime (unslaked)	4 "
Water	50 gallons.

Dissolve the copper in half of the water used, suspending the crystals in a sack in the water.

Slack the lime slowly, and then dilute to half the full quanity of water.

Pour one solution into the other, stirring constantly. Stir the mixture before using. If the potassium ferrocyanide test is not used, it might be well to add another pound of lime.

If by further experiment it should be shown that the disease is introduced abundantly by means of the seed, it will be necessary to treat the seed with hot water, copper sulfate solution, or some other fungicide. That the seed of beets will readily withstand such treatment is shown in the following table :—

EFFECT OF HOT WATER AND COPPER SULFATE SOLUTION ON GERMINATION OF BEET SEED.

No.	Nov. 4, 100 seed treated with	Time.	Plants germ. Nov. 6.	Plonts germ. Nov. 8, addit.	Plants germ. Nov. 14, addit.	Total germinated, also per cent.
1	Hot water 130°F.....	5 mins.	60	14	3	77
2	" 130°F.....	5 "	11	11	71	93
3	" 130°F.....	10 "	7	28	53	88
4	" 130°F.....	10 "	62	18	12	92
5	Check, water........	10 "	64	26	9	99
6	" "	10 "	48	15	21	84
7	Copper sulfate. 1-64..	6 hrs.	83	11	3	97
8	" " 1-64..	6 "	80	16	0	96
9	" " 1-128.	6 "	87	10	1	98
10	" " 1-128.	6 "	78	17	0	95
11	Check, water........	6 "	54	21	13	88
12	" "	6 "	69	10	9	88
13	Copper sulfate 1-64..	18 "	92	7	0	99
14	" " 1-64..	18 "	69	30	0	99
15	" " 1-128.	18 "	91	6	0	97
16	" " 1-128.	18 "	82	13	3	98
17	Check, water........	18 "	84	3	1	88
18	" "	18 "	50	40	3	93

No.	Nov. 1, 100 seed treated with	Time.	Plants germ. Nov. 24.	Plants germ. Nov. 27, addit.	Plants germ. Nov. 29, addit.	Total germinated, also per cent.
19	Copper sulfate 1- 8..	6 hrs.	75	12	4	91
20	" " 1-16..	6 "	80	16	1	97
21	" " 1-24..	6 "	82	16	1	99
22	" " 1-32..	6 "	71	11	1	83
23	Check, water.......	6 "	66	27	2	95
24	Copper sulfate 1- 8..	18 "	74	25	1	100
25	" " 1-16..	18 "	52	36	1	89
26	" " 1-24..	18 "	62	35	2	99
27	" " 1-32..	18 "	61	32	5	98
28	Check, water..... .	18 "	41	33	4	78

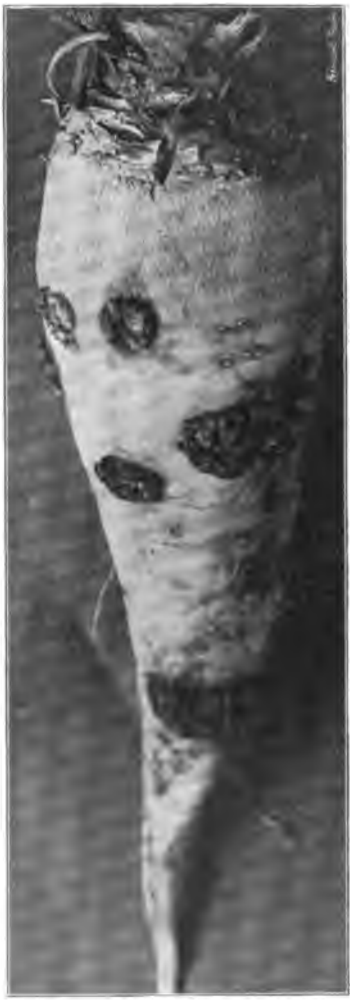
In the above experiment nos. 1–18 were germinated on moist filter paper, while with nos. 19–28 moist sand was used. The check lots were soaked for a corresponding period in water, since soaking the seed is often resorted to in practice. In general, even the strong solutions of copper sulfate gave slightly better results than the water; and germination was often slightly hastened. In a preliminary test, the germination was very markedly in favor of the copper treated seed; but since the conditions were abnormally close and moist, the exclusion of bacteria by the copper solution might have caused the apparently excessive benefit.

It remains to be determined, however, if it is desirable to treat the seed for the prevention of the leaf-spot.

III. BEET SCAB (*Oospora scabies* Thaxter).

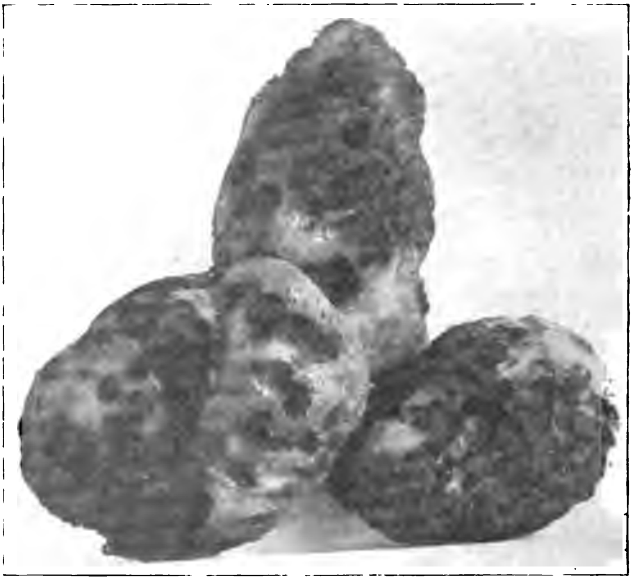
a. Appearance of the Disease.

The smooth surface of the beet root may often be disfigured by warty or scabby excresences. The texture of these injuries is somewhat corky or spongy, and the larger diseased areas will show that the injury is not entirely superficial, but to some extent alters the tissues immediately underlying such areas. The frontispiece shows two beets affected in a characteristic manner. The disease begins as small irregularities either widely scattered or clustered. Individual ones spread in extent, and groups often become united, so that in time it may spread over large areas, or small isolated areas may remain. One often notices a tendency for the scabby spots to be arranged in more or



62.—*Beet scab.*

less definite bands, often just at the surface of the ground. The diseased bands, or areas, may, however, appear much lower, as in figure 62. It is very probable that this is determined by soil and moisture conditions. The scabby protuberances are abnormal developments of corky tissue stimulated to excessive growth by the presence of the fungus. Professor Arthur has noted sunken scabby spots on the surface of the beet, and he explains these as early injuries which failed to develop further, when the conditions were probably unfavorable, and future growth of the beet has left them rather as pits than as excrescences.



63.—*Scabby potatoes.*

b. The Cause of the Disease and Its Prevention.

In 1890 Professor Thaxter discovered that potato scab is caused by the growth on the surface of the tuber of a fungus which he named *Oospora scabies*. When scabby potatoes, such as are represented in figure 63, are placed in a moist chamber, a light, grayish, mould-like growth of the fungus may appear on the surface; and it was by inoculations with pure cultures of this fungus that he was able to reproduce the disease on healthy tubers. The following year Professor Bolley found the scab of beets abundantly, and the microscopic evidence which he obtained indicated that the fungus was the same in both cases. He furthermore ascertained that in all cases when the beet scab was abundant, potatoes had been grown on the soil, either the previous year or somewhat earlier. Working independently, at about the same time, Professor Arthur came to similar conclusions about the identity of these two forms of scab; and a single decisive experiment in the transfer of scab from potato to beet was reported by him. Since that time there has been abundant general evidence to establish the fact that scabby beets may be expected if the seed are sown on land which has recently produced scabby potatoes. On the College Farm during the past season it has been very significant that the land producing scabby potatoes the previous season, produced scabby beets last season, while infected soil produced beets free from the disease.

The remedy cannot consist in this instance in the treatment of the seed, since the seed do not disseminate the disease; nor can it consist in the treatment of the land, since the experiments with liming, sulfuring, etc. have not given satisfactory results. The only course open, then, is the one of avoiding for the growth of beets any soil, which, during several years previous, has produced scabby beets.

B. M. DUGGAR.

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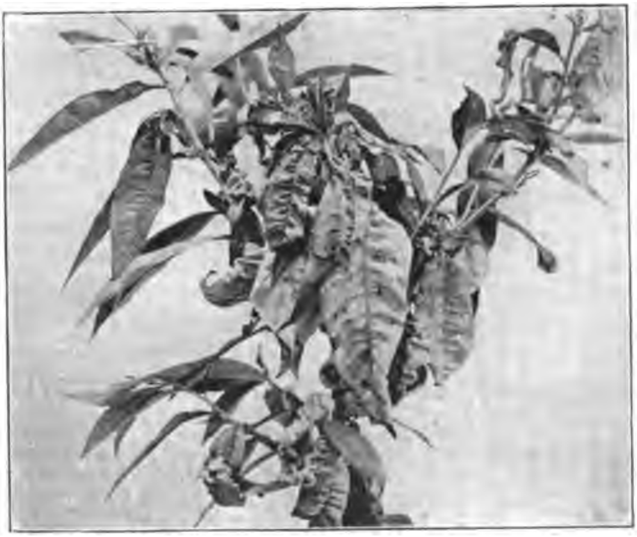
Bulletin 164. February, 1899.
Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

BOTANICAL DIVISION.

PEACH LEAF-CURL

AND NOTES ON THE

Shot-Hole Effect of Peaches and Plums.



By B. M. DUGGAR.

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THE HONORABLE COMMISSIONER OF AGRICULTURE,
ALBANY, N. Y.

Sir: Of the many diseases with which the fruit-grower has to contend, probably no one has been more generally prevalent during the past season than the peach leaf-curl. Wherever horticultural schools or meetings have been held, questions have come up concerning this disease and its treatment.

Moreover, the greater part of the correspondence referred to the mycologist during the spring of 1898 was in regard to the peach leaf-curl fungus and remedies for the same; fortunately, experiments relative to preventive treatment were already under way.

In this bulletin, Mr. Duggar has given a brief and clear account of the fungus causing the leaf-curl, and he has outlined a treatment which, under difficult conditions, has proved most satisfactory. The peach leaf-curl is one of the three great enemies of the peach-growing industry and like the other two, the yellows and the borer, if neglected or if treated unintelligently, the orchard soon becomes unprofitable, and finally is entirely destroyed.

I. P. ROBERTS, Director.

PEACH LEAF-CURL AND NOTES ON THE SHOT-HOLE EFFECT OF PEACHES AND PLUMS.

I. PEACH LEAF-CURL.*

a. General Remarks.

In bulletin 73 of this Experiment Station a complete account was given of the fungi causing leaf-curl and plum-pockets on many members of the genus Prunus. In the present discussion of the leaf-curl of the peach it will be unnecessary to go into technical details; but in order, as far as possible, to have a reason for that which is done, or recommended, a general account of the life history of the fungus must be included.

Peach leaf-curl is a disease which has long been known to the orchardist as well as to the botanist; and since the seasons of 1897 and 1898, there are probably very few peach growers in the state who are unfamiliar with the disease. The inquiries received during the past spring concerning this disease were so numerous that it has seemed important to give to the growers the results of the work of a single season, along with those results which have been elsewhere obtained. Many of the inquiries have sought a remedy only, but still others have desired a knowledge of the cause; and a general treatment of the subject is necessary.

b. Appearance of the Disease.

Peach leaves affected with the curl can often be detected as soon as the leaf buds have opened to a slight extent A roughened surface of the young leaf, and an excess of coloring are usually the first indications. As the young leaves rapidly assume their normal size, this curling and arching of the blades is more prominent. Sometimes there is distortion in a small area only, and again the entire blade may be affected. The curling of the edges of the leaves may be upward or downward, or the upper surface of the leaf may be gradually arched from base to tip. When the leaf is full grown, the diseased areas may be reddish green ; but usually the green color is largely lost and a pale discoloration characterizes diseased parts. The frontispiece and figure 64 show the appearance of the disease on a cluster of leaves terminating a shoot. Figure 64 also shows another point to be observed. Not only are leaf and leaf-stalk affected, but the terminal part of the shoot becomes much enlarged, and also pale in color. The fungus is then thoroughly established in

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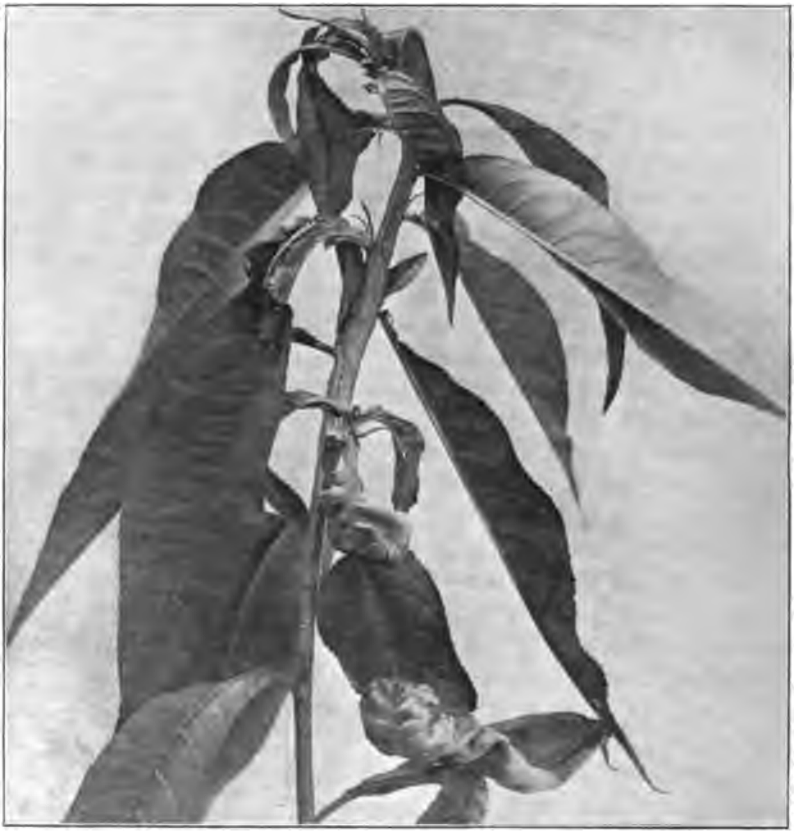
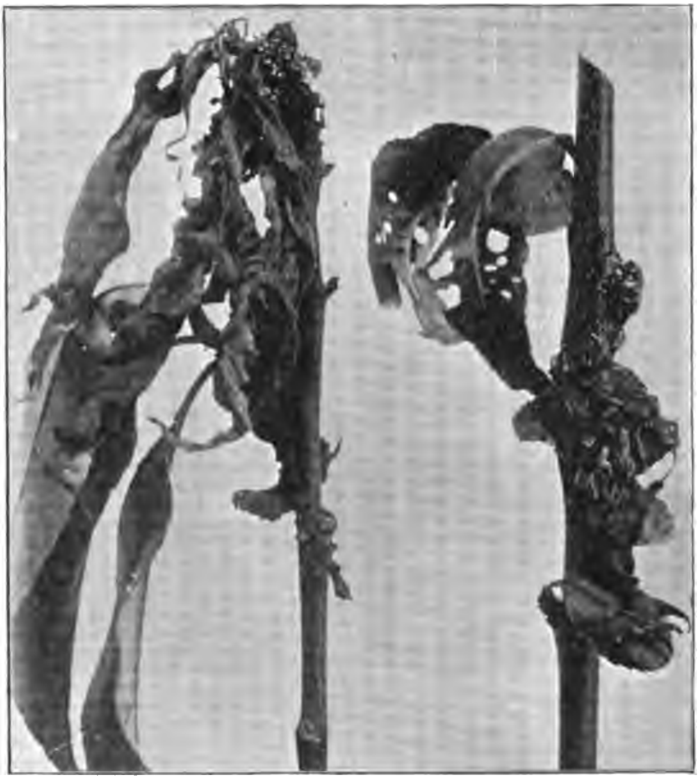
* *Exoascus deformans* (Berk.) Fuckel.



64.—*A terminal shoot with both leaves and twig affected by the leaf-curl fungus.*

the tip of the branch, and the significance of this is apparent later on.

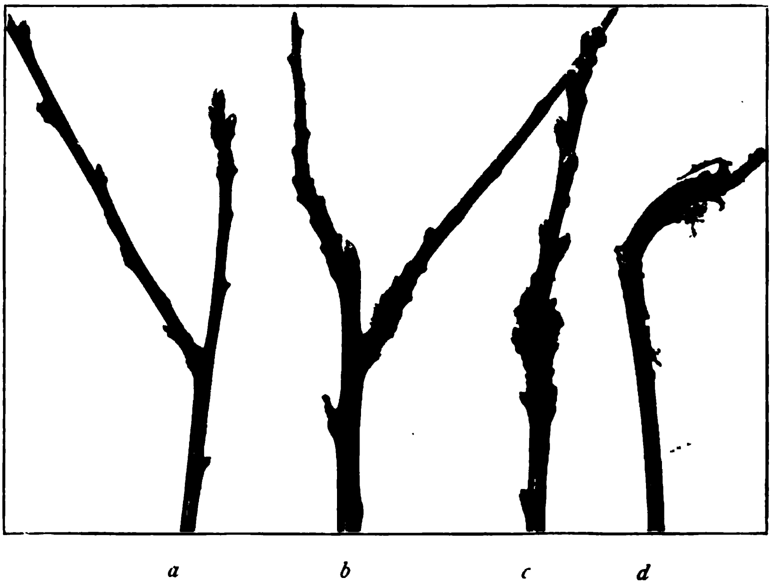
The leaves soon become grayish or mealy in appearance. This appearance is due to the fact that the fungus is fruiting, producing the spores which are to disseminate the disease. After the grayish color appears, the affected leaves gradually dry up and fall off. In this latitude the defoliation from such injuries usually occurs late in June.



65 —*Peach curl and gummosis.*

In the late stages of this curl disease, as with some other peach diseases, gummy exudations are often noted on those twigs which are enlarged by the fungus; or these may occur even on the large branches where a diseased cluster of leaves has been attached. Figure 65 shows the condition often called gummosis.

Defoliation of the entire tree does not necessarily mean the death of the tree; but it does mean the death of many twigs, and lessened vitality. New buds, or rather some of the sleeping or dormant buds open and the tree attempts to supply itself with new and healthy foliage. It is very seldom that this fresh foliage is badly affected by the curl; and it is possible to account for whatever curl is now evident as having come directly from diseased buds or twigs.



66.—*a, healthy twig; b and c, twigs in which the leaf-curl fungus is wintering; and d, twig killed by the fungus.*

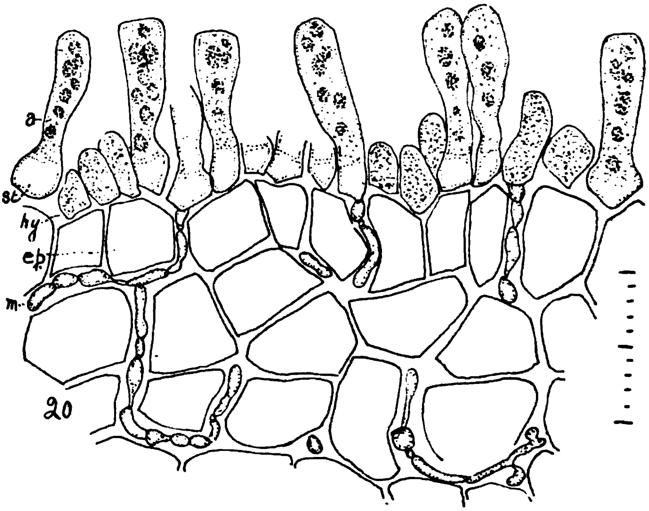
The new shoot growing out from a diseased terminal bud may grow entirely out of the disease, but the swollen part remains below. Thus, when the season's growth is done and the autumn at hand, these swollen areas may mark out the recovery of shoots; but they also indicate where the fungus rests; and they are warnings of danger for another season. Figure 66, *b* and *c*, show the appearance of twigs in which the fungus is wintering; *a*, a twig of the same age which is perfectly normal; and *d*, a twig killed by the presence of the fungus in its tip.

c. Life History of the Fungus.

In this latitude it is usually the latter part of May that the curl is most pronounced, and the grayish appearance is evident soon afterward on all diseased leaves, and on both surfaces of such leaves. The surface is evidently covered with a dense close growth, somewhat mould-like in character. As previously mentioned, the fungus which causes the curl is then fruiting, forming the spores which are to disseminate the disease; but this cannot be seen by the eye alone. Examining under the microscope some of the close growth scraped from the surface of diseased areas, numerous short, erect, thread-like growths (fertile hyphae) will be evident, as in figure 67. Close examination at the time that the fungus is mature shows that these erect hyphae are sac-like in appearance (the asci), and they usually contain eight oval bodies called the spores. In the asci the spores may sprout or bud, forming numerous conidia. After these spores or conidia are mature, they are soon set free from the sac-like structures; and being so minute and light, they are ready to be borne about by the wind. When they fall upon vulnerable parts of other trees, they are in readiness to grow into the tissue and to produce the disease again.

The fruit of the fungus is produced on the surface of the leaf, but the true vegetative state of the fungus is within the tissues of the leaf and of the young shoots. The threads, or filaments, which make up this vegetative state pass in between the cells of the leaf, and it is the irritation due to the presence of these fungous filaments (the mycelium) which causes the leaf to become distorted in form. Passing into the young shoot, the fungus is in a condition to pass the winter in situ, provided the twig lives, without having to trust to the fortune of winds and rains, as is the case with the spore.

It is unfortunate that the exact fate of the more fortunate spores is not known. Since the second growth of leaves is not badly infested by the curl, the spores do not produce the disease again immediately, it seems. One of two possibilities is then open; either (1) to germinate immediately and infect the buds which will open the next season; or (2) to be hidden away about the twigs, in the bud scales, or even on the ground about the tree, and there to pass the winter, germinating the next spring. On leaf surfaces of its host plant Sadebeck* has germinated the spores of a closely related species growing on Alnus. This took place, apparently, soon after the spores were produced. It is hoped that some studies now under way will throw light upon this important matter,—important because treatment can be made more effective the more complete is our knowledge concerning time and method of infection. At present, the results from preventive treatments indicate that normal infections take place in the spring.



67.—*Cross section of a part of a leaf affected with leaf-curl, showing the fruiting of the fungus. (From Bulletin 73, by Professor Geo. F. Atkinson.*

d. Conditions Affecting the Abundance of the Leaf-Curl.

The sporadic occurrence of the leaf-curl is rather remarkable. In many sections of the State there was very little in 1896. The same sections in 1897 saw a large increase in the abundance of the disease, and the past season was characterized by unusual injuries from this cause. This wave of increasing abundance during the past few years seems to have extended quite generally through the Northern States, judging from inquiries received, and from the activity of experimenters in this field of work at various experiment stations.

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* Unters. über d. Pilzgattung Exoascus, u. d. durch dieselbe um Hamburg hervorgerufen Baumkrankheiten. Abgedruck a. d. Jahrb. d. Wiss. Anst. p. 102, 1883, Hamburg.

Attempts have been made specifically to define the conditions which encourage the curl. Some have asserted that a cool, moist spring is most conducive to its abundance. The time of infection, however, should be determined, it seems, before any satisfactory explanation may be given. It is quite reasonable to suppose that the conditions prevailing at the time the spores of the fungus are being disseminated, or the conditions prevailing at the time the spores germinate to infect the buds or leaves would be the factors to determine the greater abundance or the less abundance of the disease the following year. If the spores of the fungus live over winter on the ground or twigs, and germinate with the first warm days of spring to infect the opening buds, then the spring conditions would seem to be of great importance in determining the amount of the disease. If, however, infections result during summer or autumn the effect of spring conditions is not apparent.

It is well known that different varieties of the peach show different degrees of susceptibility to the attacks of leaf-curl. The same is often found to be true of other plants attacked by other fungous diseases, and it can only be explained by constitutional differences in the varieties. Among varieties of peaches very susceptible to the curl, Selby* mentions Mountain Rose, Old Mixon, Globe, Elberta, Scott's Nonpareil, Red Cheek, and others. Such a list will, in all probability, vary with the place, and I have examined some orchards of many varieties in which none were exempt.

e. Remedies.

The early experiments made to determine the value of fungicides for the prevention of peach curl were unsatisfactory both

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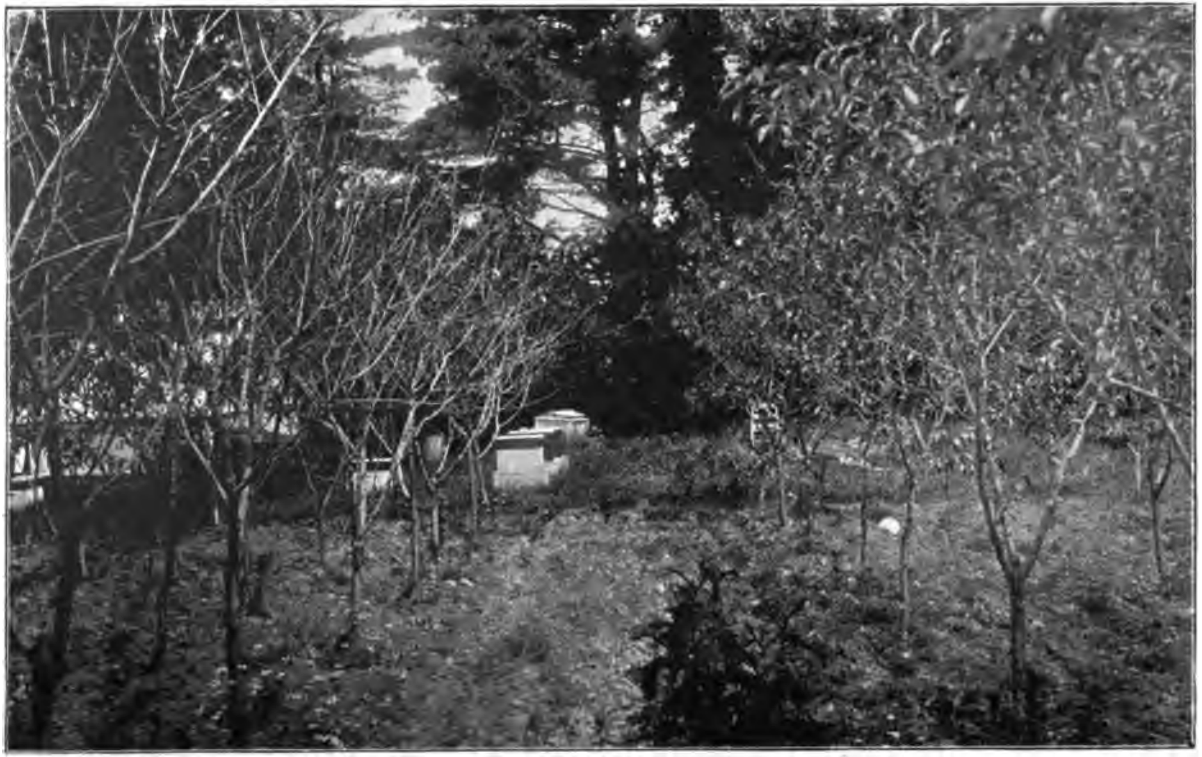
*Bulletin 92, Ohio Agricultural Exp. Station, 1898.



68.—*Photograph showing rows 2 and 3; row 2, on the right, sprayed early with Bordeaux mixture; row 3, on the left, sprayed late with Bordeaux.*

because the fungicides themselves often injured the leaves, and also because the best time for spraying was not apparent from our knowledge of the fungus. Much of the later work has been to demonstrate that spraying one season lessons the disease during the succeeding season. At the time that my experiments were begun, I was not aware of other results.

In an orchard of young trees closely set and used for some experiments with borers, by M. V. Slingerland, leaf-curl appeared in 1896. The following year it was so abundant as to cause almost entire defoliation, and there was every promise of an abundant reappearance of the disease in 1898. These trees were so close together that they were especially desirable for such work, since it would be very probable that any remedy proving more or less effective under such conditions would be even more effective under ordinary circumstances. There was also the additional advantage that the trees were all known to have been affected the previous year. Several varieties were represented in the orchard, and the experimental rows were run across varieties, so as to eliminate any error on this score.

The treatments given, and dates of spraying, were as follows :*

Row 1. Check.
2. Bordeaux mixture, April 8, May 10, May 21, June 8.
3. Bordeaux mixture, May 10, May 21, June 8.
4. Bordeaux mixture, April 8, Potassium sulfide, May 10, May 21, June 8.
5. Check.
6. Potassium sulfide, May 10, May 21, June 8.
7. Bordeaux mixture, April 8, Ammon. copper carbonate, May 10, May 21, June 8.
8. Ammon. copper carbonate, May 10, 21, June 8.

In the statement of results the abundance of the disease the previous year must be remembered, for it is very evident that no hope could be entertained for securing exemption from the disease where the fungus had been carried over winter in the twigs.

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*In this experimental work Mr. H. P. Gould coöperated with me.

Notes on the results at the different dates may be stated thus:

Apr. 8.—Buds hardly beginning to swell. (1st spraying.)

May 10.—Soon after pollination of the flowers; petals dropping, and young leaves out from one-half to one inch long. Even at this time a large number show that the curl is present, by increased reddish coloration, but almost no distortion of surface. Microscopic examination showed that there was yet no fruiting of the fungus. (2d spraying.)

May 21.—Curl showing abundantly in the orchard both on leaves and twigs; fungus not yet fruiting. (3d spraying.)

June 1.—Row 1, (check). Very bad; almost every leaf on the tree affected.

Row 2, (Bordeaux early). Very good, curl mostly confined to some of the tips of growing twigs.

Row 3, (Bordeaux late). Very bad; almost every leaf affected.

Row 4, (Bordeaux early, Potas. sulf. late). Very good; perhaps slightly more curl than in row 2.

Row 5, (Check). Very bad; almost every leaf affected.

Row 6, (Potas. sulf. late). Very bad; a large majority of the leaves affected.

Row 7, (Bordeaux early, Am. cu. carb. late). Very good; almost equal to No. 2.

Row 8, (Am. copper carb. late). Very bad; almost every leaf affected.

Particular attention should here be directed to the fact that where Bordeaux mixture was used before the buds swelled, the foliage of the trees was very largely entirely free from the curl, even during this first year of treatment; and this was true irrespective of the mixture subsequently used (compare rows 2, 4, and 7). Unfortunately there was no row which received the first treatment only.

June 8.—On this date, the time of the last application, the leaves badly affected were falling abundantly. Soon after this time the photograph was taken from which figure 68 is reproduced. This figure shows the difference between the row sprayed late with Bordeaux, and the row sprayed both early and late with Bordeaux, rows 2 and 3.

The final results indicate very significantly that at most there is very slight effect from the treatments subsequent to the early treatment with Bordeaux, and that the early treatment is the one of importance for the protection of the foliage during the same year. Perhaps the subsequent treatments may prove of value as to the amount of the curl the following year, and this is what others have already demonstrated.

Since securing these results, I have had correspondence with some orchardists who had sprayed peach trees for various diseases. With few exceptions, those who have sprayed early have been those successful in the prevention of the curl.

A very interesting result has been reported by Mr. A. I. Loop of North East Penn. So far as the prevention of curl is concerned, the benefit was accidental; but the value of early spraying is again demonstrated. From his letter, I quote as follows, "The experiment was to try the effect of whitening for the protection of buds during winter. The directions given by Professor Whitten in his bulletin issued at Columbia, Mo., were followed. A selection was made about the center of a block of 4000 trees; about a dozen trees across the rows, including different varieties, were treated. The first application was made

69.—*A branch from a tree in row 2, sprayed early with Bordeaux mixture.*

the first week in January, using his regular milk and lime formula. The next was the same treatment on the first of February. They were again treated about the first of March, but instead of milk we used dextrine. * * * As to results,—we could discover no difference in time of blossoming between the treated and untreated trees. * * * We discovered one thing, however, that we thought remarkable. All of our trees were considerably affected with curl-leaf, but we found these treated trees to be almost absolutely free from it. At least one-half of these trees have not shown a single diseased leaf up to the present time (July 27) ; about one-half of them had one or two diseased leaves. The adjoining trees on both sides and on each end of the treated trees without exception showed many curled leaves, from 25 per cent to 75 per cent of all of the leaves on the trees being affected."

The above is very conclusive, even with a fungicide, dilute whitewash, which we have not held in high esteem when used alone. For this early treatment it has one of the special advantages of Bordeaux mixture, that of adhering well.

In the Year Book of the U. S. Dept. of Agriculture, 1897, page 110, there are given some noteworthy figures concerning the gains which growers on the Pacific coast have enjoyed by following out certain lines of treatment suggested by the Department. This report was not out until our experiments were practically complete, and in it no statement is made of the time when the applications were made. I have since learned, however, that special stress is laid upon the early spraying. The results at other experiment stations, notably at Ohio, largely confirm what has already been said concerning remedies.

Special recommendations :—With our present knowledge of peach leaf-curl, the following may be suggested :

1st. Spray thoroughly with strong Bordeaux mixture just previous to the swelling of the buds, late in March, or very early in April seems desirable in this latitude.

2d. Spray again with weaker Bordeaux as soon as the petals of the flower have fallen, or after the work of the bees is over.

3d. Spray again with weak Bordeaux when the first leaves are just full grown, or at just about the time that the spores of the fungus are developing.

Discussion of recommendations :

1st. Why not spray in midwinter ? Midwinter spraying may be quite effective, but there is every reason to believe that the April spraying will be better ; for if that is near the time that the buds are infected, the spores will then be more readily killed. If a time when other work is not pressing is of first importance, spray earlier. Why not use copper sulfate solution? It may be quite as efficient, but Bordeaux adheres better and would be more likely to prevent infections throughout a period.

2d. Why? Late infections by spores from the ground or from neighboring fields may thus be guarded against.

3d. This spraying is to cover the leaves with Bordeaux at about the time the fungus is fruiting, hoping not only to prevent summer infections, but to cover places where the spores may lodge in order to pass the winter.

70.—*A branch from a tree in row 3 sprayed late with Bordeaux mixture.*

The Bordeaux Mixture.

In making the first spraying, the all-important one, strong Bordeaux mixture may be used ; and every twig should be so well covered that the blue color appears as a distinct coating after the application has dried. However, under certain conditions, the foliage of the peach seems to be easily injured by spraying with Bordeaux mixture. With weak Bordeaux mixture properly made, I have not been able to produce any injury on the trees experimented upon.

The customary formula for Bordeaux mixture is:

Copper sulfate (blue vitriol)	6 lbs.
Unslaked lime (good quality)	4 lbs.
Water	50 gallons.

In spraying the foliage of peach trees, reduce the copper sulfate to four pounds. Even this may seem strong. It should not, however, be condemned until tried; and when tried the mixture should be made by the one method which has been most successful.* To dissolve the copper sulfate, suspend it in a coarse sack in a barrel containing twenty-five gallons of water. Slack the lime (use only the best) slowly, and then dilute it to twenty-five gallons. Pour the two together in this dilute form, stirring for a few minutes. Stir before using. If large quantities of the mixture are desired, stock solutions may be made as usual. Dissolve say fifty pounds of the copper sulfate in a barrel containing as many gallons of water. The stock solution of lime may be made of the same strength. Then each gallon means a pound of the substance wanted. When the mixture is made, dilute each solution separately before pouring them together.

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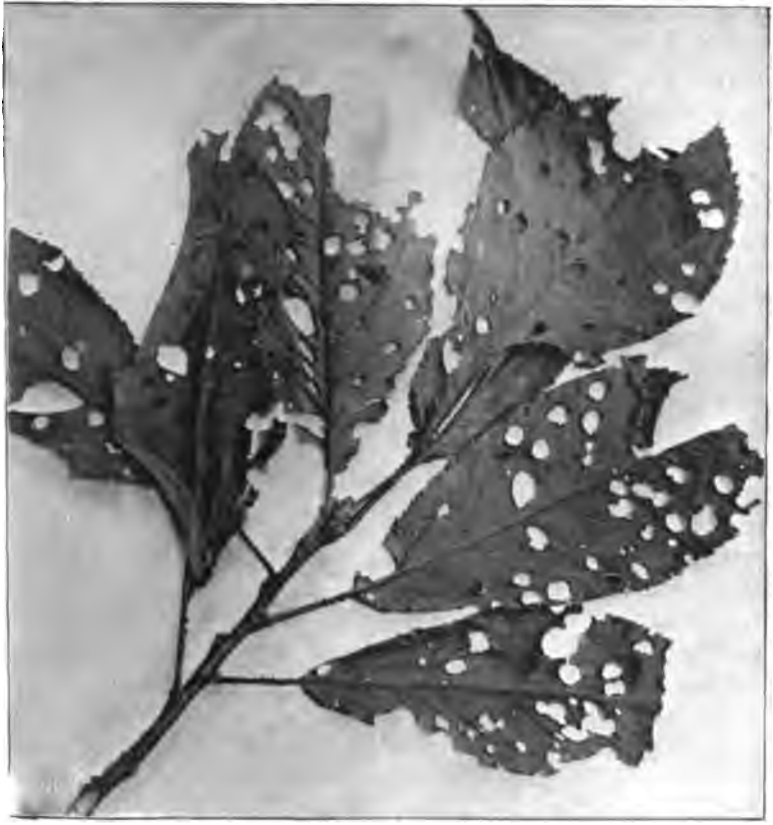
* See *Farmers' Bulletin* No. 38, U. S. Dept. Agriculture, p. 6.

II. NOTES ON THE SHOT-HOLE EFFECT OF PEACHES AND PLUMS.*

During several years past I have received from a few correspondents, leaves of the plum and of the peach badly affected with a shot-hole injury. The interesting feature of the cases mentioned was the fact that this injury occurred where the trees



71—*Shot-hole effect on Japan plum sprayed with improperly made Bordeaux mixture.*

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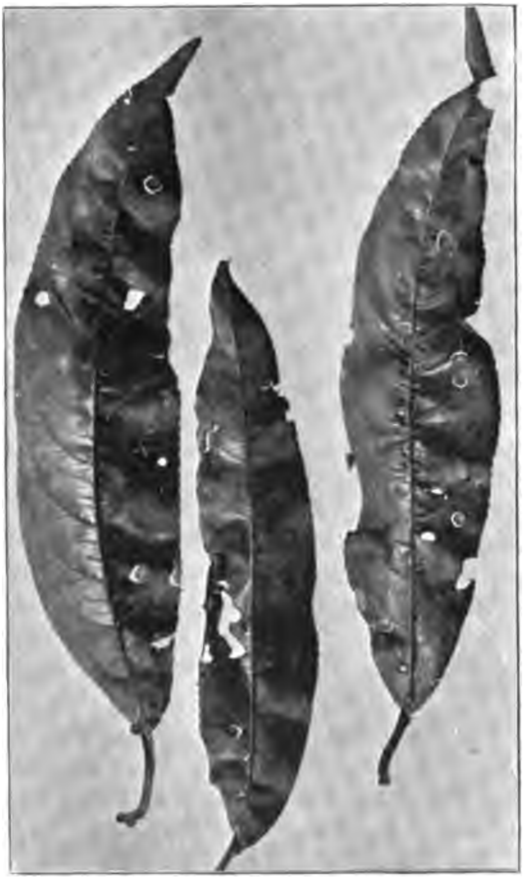
* Fuller details upon this subject will be found under the same title in the Proceedings of the Soc. for Promotion of Agl. Sci., 1898.

had been abundantly sprayed. From observations already made, I had suspected that other causes besides the shot-hole fungus might be responsible for some of the troubles referred to me. In one case, especially, there was an unusual appearance of the shot-hole effect in a large orchard soon after the application of Bordeaux mixture.

On the horticultural grounds of the Experiment Station, during the season of '97, Mr. H. P. Gould called my attention to the abundance of the shot-hole effect on Japan plums which he had sprayed constantly. I had then completed some experiments with the production of such injuries by means of substances injurious to the foliage; and the results indicated clearly that injuries to the foliage by many deleterious chemical agents might produce the characteristic shot-hole appearance.

It was reasonable to believe that spraying might have the same effect under certain conditions. Later experiments were made to test the effect of some copper compounds upon the foliage of the peach and of the apricot, and comparatively upon plums of the native, domestica, and Japan groups. In general the peaches, apricots, and plums of the native and domestica groups were free from any shot-hole effect; but the Japan plums generally indicated some injuries of this kind. The entire orchard had been sprayed with Bordeaux mixture tested with potassium ferrocyanide. A few trees of each kind mentioned were then sprayed with properly prepared Bordeaux mixture, with Bordeaux mixture containing an excess of copper, with Bordeaux made by the use of poor lime, and with a solution of copper sulfate containing one pound of the compound to about 15 gallons of water.

The properly prepared Bordeaux produced no injury except upon the Japan plum (Burbank); but there was an evident injury in the latter case. The improperly made Bordeaux mixtures affected the peach and the Japan plum to a marked extent, a photograph of injuries to the latter being shown in figure 71. By the same mixture the apricot and the native plum (Yellow Transparent) were somewhat injured, while the effect upon the domestica (Empire) was scarcely noticeable. The copper sulfate solution of course produced injury in all cases, but this injury was very little in the case of the domestica, and somewhat more pronounced with the native. On the Japan plum and on the apricot a marked shot-hole effect was produced, followed by considerable defoliation, and on the peach there was complete defoliation within a few days.



72.—*Shot-hole effect on peach produced by weather conditions.*

The shot-hole effect abundant among Japan plums in the orchard was again examined, but there was no indication of a causal fungus; and very significant was the fact that young shoots growing out beyond the region covered by the spraying were wholly free from such injuries. There was no doubt that this general appearance of a shot-hole fungus on the Japan plums was due directly to the spraying. An unsprayed orchard of Burbank and Abundance in the vicinity showed no shot-hole injury whatever.

Later experiments on the Chabot plum confirmed the previous work, indicating that under certain conditions the Bordeaux mixture may be injurious to the foliage of the Japan plums, much more so, in fact, than to that of the peach.

Among the varieties which have shown the greatest injury from spraying during the past season may be mentioned, Willard, Chabot, Douglass, Berckmans, Earliest of All, Georgeson, Ogon Kelsey, Blood No. 3, and Abundance. Burbank and Red June were also affected. Forest Garden was the only native plum noticeably affected, and all varieties of the domestica group were conspicuously free from the trouble.

An examination of specimens of the various fungi affecting the peach and the plum will show that, with the exception of leaf-curl, mildew, and a few others, these fungi are very generally productive of a shot-hole effect. The fungus most abundant in a particular region will be the one there designated as a shot-hole fungus. With these facts at hand, my experiments with fungicides and other chemical agents above referred to were made. These results are sufficient to demonstrate that this shot-hole effect is a peculiar physiological reaction of the plant to injuries of many kinds.

Figure 72 shows an effect of this kind produced by peculiar causes. The tree was blown down during a summer rain storm. The rain was followed by a hot, steaming afternoon; and in about two days the shot-hole effect was evident.

After an examination of a number of plum orchards in this State, I find the Japan plums so free from shot-hole fungi that I see no necessity of spraying them for these particular diseases and thus encouraging a shot-hole effect due to spraying.

Where the plum rot is bad, it will be necessary to spray, and one must disregard the slight injuries to the foliage resulting from the use of properly made Bordeaux mixture.

B. M. DUGGAR.

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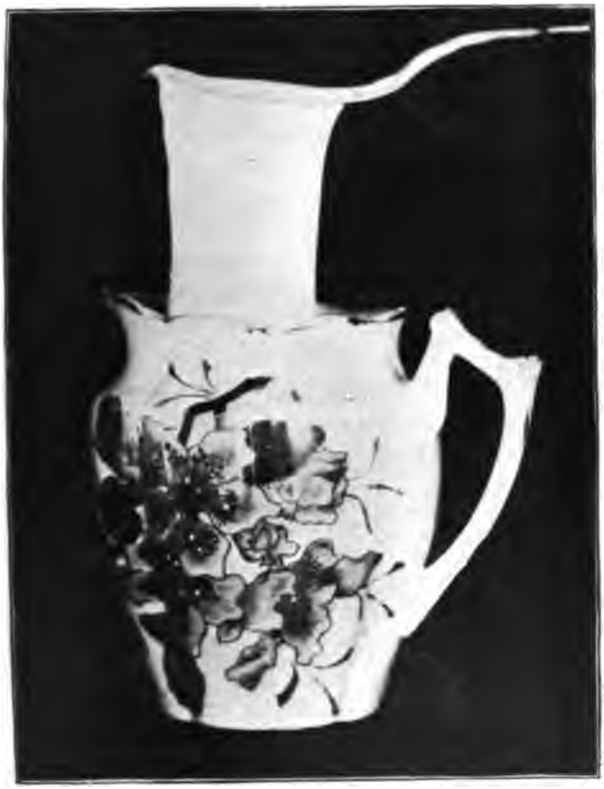
Bulletin 165. **March, 1899.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

DAIRY DIVISION.

Ropiness in Milk and Cream.



By ARCHIBALD R. WARD.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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THE HONORABLE COMMISSIONER OF AGRICULTURE,
ALBANY, N. Y.

Sir: This bulletin is submitted for publication under Chapter 67 of the Laws of 1898.

The abnormally viscid condition of milk and cream, commonly designated "ropy," is familiar to many dairymen, and its occurrence causes most serious loss.

This publication contains a brief résumé of the conclusions reached by earlier investigators together with a detailed account of the investigations carried on by the College of Agriculture. The conclusions reached in this publication, based upon actual experience and supported by those of other investigators, indicate that this trouble may be arrested or prevented by the exercise of precautionary measures intelligently directed.

Further, it has been found that ropiness in milk is a trouble which may be transmitted by the unclean milk utensils of the dealer or by those of the consumer. Because of this fact, certain dealers have been unjustly accused of delivering faulty milk, when the true cause was the unclean milk utensils used by the consumer. Therefore the information conveyed by this bulletin is of interest to those dealers who, although exempt from this trouble, are anxious to preserve a good name, as well as to those suffering losses as a result of faulty methods.

I. P. ROBERTS, Director.

DESCRIPTION OF PLATE.

1. *Bacillus lactis viscosus* from an agar slant culture eight days old, stained with carbol fuchsin. × 1,000. A loopful of the viscid growth was drawn across the cover-glass. The linear arrangement of the organisms probably is due to the capsules.

2. *Bacillus lactis viscosus* from a bouillon culture three days old, stained with carbol fuchsin. × 1,000. This preparation shows the extreme variation in size and the polar stain exhibited by this organism when grown in bouillion.

3. Drawing from a cover-glass preparation from a milk culture of *Bacillus lactis viscosus* twenty-four days old, stained with carbol fuchsin. × 1,000. The presence of a capsule is indicated by the unstained areas surrounding the organisms.

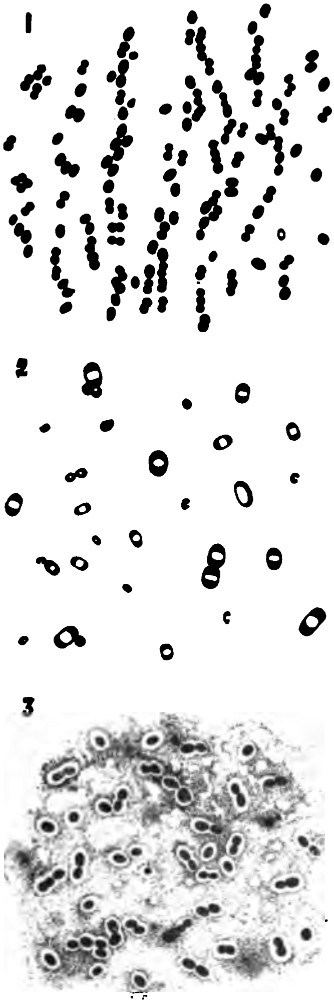

Plate IV.—*Bacillus lactis viscosus.*

ROPINESS IN MILK AND CREAM.

BY ARCHIBALD R. WARD.

Ropiness in milk is one of the most serious troubles with which milk dealers have to contend. This condition which is objectionable more on account of its unwholesome appearance than from any known harmful effect which it produces, has received its popular designation from the viscid, slimy, consistency which characterizes the affected milk. The cause has been found to be the action of certain bacteria, and a number of apparently different species have been described as possessing the power of producing the ropy condition. Among those who have written on this subject should be mentioned Adametz, Loeffler, Guillebeau and Marshall. Nevertheless, few definite determinations have been made concerning the natural habitat of these particular species of bacteria and the channels through which they gain entrance to the milk. Further information on these points is especially desired in order to successfully combat the trouble and to prevent its recurrence.

This trouble which is wide spread and of considerable economic importance to milk dealers and butter makers, should not be confused with the abnormal changes in milk which accompany an inflamed condition of the udder frequently called "garget." Milk drawn from udders in this condition is more or less thickened by the presence of pus or may in addition contain white, tough, solid masses of casein which pass through the duct of the teat with more or less difficulty. Milk in such condition is by some called ropy and consequently it has been asserted that a diseased condition of the udder is the cause of all ropy milk. The investigations which have heretofore been made do not throw any definite light upon this alleged cause. They do not suggest a necessary dependence upon a diseased condition of the udder, although they do not preclude the possibility of such a combination. The fact that each of the authors referred to was able to isolate a species of bacteria capable of producing this trouble under artificial conditions, suggests that its source is very likely without, rather than within the udder as suggested by the "garget theory." Von Freudenreich isolated a gas producing bacillus* from the udder of a cow which was suffering from mammitis. In addition to establishing its etiological relation to the diseased condition of the gland, Guillebeau, who studied the organism isolated by von Freudenreich, found the bacillus to produce viscosity in milk. As this organism has not been reported by others as causing ropiness in milk and as it is associated with mammitis, in which case the milk is of no commercial value, it is of little significance when considered as a cause of ropy milk.

Adametz† has shown that *Bacillus lactis viscosus* possesses a slimy viscid capsule which envelops each organism and by reason of this is enabled to bring about a corresponding condition in milk when the individuals are present in sufficient numbers. In the year following the discovery of this bacillus in brook water, Adametz again isolated it from a sample of milk obtained from a dairy in which trouble from ropy milk was experienced intermittently. Although not verified by bacteriologic examination, the indirect cause of each separate outbreak was believed to be the occasional use of water from a certain well. It was observed that trouble was experienced upon each occasion when because of drought it became necessary to use the water of this well, and immunity from trouble was attained by avoiding the use of the water in question.

Mention of this bacillus described by Adametz is to be found in several works upon bacteriology. In each reference a statement is made to the effect that the viscid change caused by *Bacillus lactis viscosus* takes place so slowly at room temperature that it can not be the cause of ropiness under ordinary conditions and that Adametz's painstaking investigations are only of a theoretical interest. After a critical reading of Adametz's paper in the *Landwirthschaftliches Jahrbücher* of 1891, it becomes evident that misconstructions have been placed upon his statements. On page 191 of the volume referred to he makes a statement of which the following is a translation: "Sterile milk inoculated with *Bacillus lactis viscosus* and kept at room temperature, shows little outward appearance of change during the first two days But the surface layer of cream is found to be ropy when tested and the increased viscosity of the skim milk below becomes evident when it is stirred." Farther on in this paper he says: "In cultures contained in test tubes where the milk is slightly exposed to the air,* the complete change of all the milk does not occur until about four weeks." Those writers who have underestimated the practical bearing of Adametz's work, seem to have labored under the impression that ropiness must necessarily appear in the depths of the milk as well as in the cream, in order to be the cause of serious trouble.

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*Landwirthschaftliches Jahrbuch der Schweiz, 1890, p. 41.

†Landwirthschaftliche Jahrbücher, 1891, p. 185. Earlier and less complete reference to this organism are to be found in the Milch Zeitung, 1889, No. 48, p. 941, abstracted in Centbl. für Bakt. und Par. Bd. VII, 1890, p. 767. Also in the Oesterreichische Monatsschrift für Thierheilkunde und Thierzucht, Jahrg XV. 1890. No. 2, p. I, abstracted in Centbl. für Bakt. und Par. Bd. VIII. 1890, p. 109.

My observations upon the occurrence of ropiness in milk in creameries in New York, and the identification of *Bacillus lactis viscosus* as the cause, show that the ropiness brought about by that organism although appearing only in the surface layer of milk, may become of considerable commercial importance.

In the summer of 1898, the appearance of ropy milk in a locality near Ithaca was brought to notice by a milk dealer, who, having suffered severely in loss of custom by its occurrence, applied to the College of Agriculture for aid. He was instructed to dampen the udders of the cows with dilute carbolic acid before each milking. This measure, which is of value in preventing filth on the udder from falling into the milk, was carried out faithfully without benefit. With the view of ascertaining facts which would lead to methods of prevention, a careful study was made of the conditions under which the outbreak occurred.

The attending conditions were as follows: All of the milk handled by this dealer was supplied by one dairy consisting of twelve cows. The surplus of milk over that disposed of on the route was used for butter making, the deep setting system of creaming being used. The cream on the surface of the cans of milk which stood in water at a temperature of from 45° to 50° F. (7°–10° C.) became viscid in from twenty-four to forty-eight hours after setting, so that it would adhere to a table fork, stringing out in a ropy mass. The frontispiece of this bulletin illustrates the typical behavior of the cream. The viscosity was more marked in the surface layer of the milk, and hence in the cream. It is for this reason that the trouble is incorrectly regarded as a fault peculiar to cream. No complaint was heard from those customers who consumed the milk within a few hours. Some of them, however, kept the milk until the following morning when the cream would be ropy.

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* The fact that *Bacillus lactis viscosus* is an obligate aerobe explains the behavior in milk observed by Adametz.

A bacteriologic examination of the ropy cream revealed the presence of *Bacillus lactis viscosus*. After isolating from the viscid cream an organism which invariably produced the ropiness in milk (or cream) when inoculated with it, further work to determine the distribution of this organism in nature and to find out through what channels the milk became infected seemed highly desirable. To accomplish this it was proposed to collect samples of the milk at each step in the processes to which it was subjected between the cows' udders and the deep setting cans where the ropiness becomes manifest. The fact that the organism grows in milk at a temperature of 54°F. (12°C.) and produces ropiness in a few days, was a valuable aid in the search since such a low temperature will prevent the rapid multiplication of most species of bacteria in milk. If the samples collected are kept at room temperature, there is no assurance that *Bacillus lactis viscosus* can be detected among the other bacteria present. By lowering the temperature the growth of most microörganisms is checked, without seriously hindering the multiplication of the one causing the ropiness. It was just this condition in the creamery which enabled that species to assert its presence in the deep setting cans.

In taking samples of milk from each cow, the udders and teats were moistened with a weak solution of carbolic acid, this being the only safeguard taken to prevent the access of dust. Glass milk bottles were scalded and kept sealed with paper covers, except at the moment the samples were drawn. The wide mouth of the bottle offered considerable opportunity for the entrance of dust particles which might convey the bacteria had the particular species in question been adhering to the udder. The twelve samples were kept cool but none became viscid.

All other samples were drawn into test tubes the mouths of which presented a smaller area for the reception of dust. The tubes had been previously plugged with cotton and heated, rendering them absolutely sterile. At one milking period two samples were taken from each cow. One was from the first milk drawn and the other from the strippings. Two more samples were taken from each cow on different days. In every case they were kept at a temperature of about 12° C., none of them becoming viscid.

Cultures were made from the milk of each one of the cows on two different days, the bacteria present in the milk of each cow being thus obtained in pure culture. From the first twelve samples, there were obtained five apparently different species none of which when grown in sterile milk brought about the viscid condition. None of the species at all resembled the organism sought. In like manner a second series of cultures was made from the milk of each of the cows with similar negative results. During the period that the cultures were being made from the milk, the ropy milk was constantly present in the creamery. The evidence from these experiments leads to the conclusion that the various species of bacteria which are always found in freshly drawn milk did not, at that particular time at least, contain among them the species capable of rendering the milk viscid. *Bacillus lactis viscosus* itself furnishes evidence in support of the conclusion that its natural habitat is not the ducts of the udder as is true of many of the bacteria found in freshly drawn milk. This microörganism does not grow so luxuriantly at the temperature of the cow's body, 37.5° C., approximately, as it does at a lower temperature. Such would probably not be the case if the organism were accustomed to living in the udder.

In addition to examining the milk samples collected, a bacteriologic examination was also made of those substances which might harbor the obnoxious organism such as stable dust, particularly that dislodged from the udder, unclean utensils and fæces. For study of the species present in the air of the stable, Petri dishes* containing a layer of nutrient agar were used. The agar surface of each was exposed to the air for a definite length of time. The bacteria in the air, thus coming in contact with the agar, would later manifest their presence by the colonies formed as a result of their rapid multiplication upon this medium. One Petri dish was exposed under the udder of each cow at some time during the period of milking, the cover of each being off for a period varying from one-fourth to one-half minute. After four or five days at a low temperature a slight growth was observed. Had *Bacillus lactis viscosus* been present, its growth would have been visible much sooner. The several species which did grow on the agar at that low temperature were quite unlike the one sought. Sterile milk was inoculated with bits of rubbish from the floor of the stable, dust from the beams overhead, cow hair, water from the drinking trough, and sawdust from the ice house. None of the samples of sterile milk thus artificially contaminated became ropy, although all underwent some sort of fermentation. Cultures were made from the fæces of a cow, but the bacteria found threw no light upon the problem.

An examination of all of the other probable sources from which the bacteria might have gained entrance to the milk having revealed nothing, attention was turned to the utensils with which the milk came in contact. It would be a very simple matter for a milk vessel which had once contained ropy milk and which had not afterward been properly cleansed, to again infect normal milk placed in it.

Upon one occasion the milk ærator in use at the farm barn was found in an unclean condition, it having been carelessly rinsed when last used. Cultures were made directly from the milk remaining in the apparatus. Several small quantities of sterile milk were exposed to infection in the pails used for milking and also by pouring through the mesh of the strainer pail. Inoculations were made directly to culture media from the accumulated mass of filth on the border of the brass strainer. Such an accumulation, although innocent in appearance, is nevertheless, teeming with bacteria which infect the milk which passes through the strainer. None of the cultures made from the accumulated filth revealed the presence of the bacteria causing ropiness, nor did any of the milk samples become viscid. It was noted, however, that the bacteria found in the filth of the ærator were identical with those found growing in the milk which had been poured over it; also that those in cultures from the filthy strainer were the same as those found in the milk poured through it. These facts are of interest as illustrating how directly filth may influence the keeping qualities of milk by introducing bacteria. It should also be noted that the filth itself cannot cause ropiness in milk, unless there are present in it the bacteria which possess that power.

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*A Petri dish is a flat, shallow, circular glass vessel with sides perpendicular to the base and provided with a closely fitting cover of the same shape.

A bit of the cloth strainer used over the top of milk cans was placed in sterile milk. Samples of the mixed milk of the dairy were collected from the milk pails, after passing through the strainer pail, after passing through the ærator and through the cloth strainer into the milk can. All of the samples were kept cool, the various fermentations going on slowly, giving opportunity for the development of ropiness. None of the samples became viscid. From this fact it was concluded that the milk did not contain *Bacillus lactis viscosus* when drawn from the udder, nor did it gain access to the milk during any of the processes to which the milk was subjected up to the time that it was taken from the barn.

It is important now to note the results obtained from a similar treatment of the milk in the creamery. The evening's milk was brought to the creamery and placed for the night in deep setting cans surrounded by ice-water. That of the morning was ærated and brought to the creamery where it was again strained before delivering. A brass wire strainer was used constantly because it was of such size as to fit over the top of the cans, forming a convenient device for holding a cloth strainer in place. For this reason all of the milk passed through the one strainer and always into deep setting cans. The milk strained in the evening remained in the cans over night. The meshes of the strainer were seriously obstructed by an accumulation of filth, the result of a lack of thorough cleaning. They had become obstructed to such an extent that the reservoir would become half full of milk before the pressure of the accumulated fluid was sufficient to force its way through the meshes. The deep setting cans were apparently clean but they were never placed where sunlight could act upon them.

The method employed in washing the tinware was closely observed. The tub of hot water in which the work was done, was, at the beginning, as hot as could be borne by the hand, but was allowed to cool so that it frequently fell to 80°F. (28°C.). After washing, the utensils were rinsed in hot water, but they were not subjected to a high temperature for a long enough time to sterilize them. So little importance was placed upon the necessity for extreme care in washing and scalding, that the woman who came daily to do merely that work, had been kept in ignorance of the occurrence of ropiness in the creamery.

Three different quantities of sterile milk were successively exposed to contamination on the surface of the strainer. Four other samples were allowed to remain for short periods in contact with the interior of the deep setting cans. All three samples contaminated from the strainer, and two from the deep setting cans became viscid. To insure that no mistake had been made, and that the viscid condition was caused by *Bacillus lactis viscosus*, the presence of that organism in each of the viscid samples was demonstrated by a bacteriologic examination.

The evidence concerning the cause of the constant ropiness of the milk at that time requires little comment. To recapitulate: The strainer through which all the milk passed was found upon two different days to possess the power of contaminating milk with the specific organism which causes ropiness. Two out of four deep setting cans examined were found in a like condition. During the time that the ropiness was occurring at the creamery, samples collected from the milk before being brought there did not become viscid. In addition, a bacteriologic examination of the probable sources of contamination at the farm gave negative results.

It may be suggested, and reasonably, that each of the sterile samples contaminated in the creamery may have received the bacteria from the air rather than from the cans. There are two reasons, for considering this improbable.

First. If the bacteria had been present in the air, and were in that manner contaminating the milk, all of the samples exposed in the vessels, and incidentally to the air, should have become viscid.

Second. The bacterium which accidentally survived the cleansing process in the utensils is the one more likely to occur under the uncleanly conditions prevailing in the particular creamery visited.

Another establishment which had suffered to a similar extent from the occurrence of ropiness was visited for the purpose of obtaining additional information. The business was conducted in a manner similar to the first except that several dairies instead of one supplied the milk. At a time when the writer was not present, the proprietor of the establishment set samples of the milk of each patron noting those which became ropy. Upon this evidence, he reported several dairies as furnishing ropy milk. In one of those so reported, experiments were made of a similar nature to those in the first case, as follows: Samples of the milk of each of the twenty-eight cows were drawn into sterile test tubes, with no precautions against the access of dust from the udder. None of the samples became viscid, although they were kept in a refrigerator for ten days. Agar plates were exposed under ten of the cows, but no growth resembling that of *Bacillus lactis viscosus* appeared. Samples of the mixed milk were collected from the milk pails, before and after flowing through the strainer pail and from that which had passed through the strainer cloth, but none became ropy.

In the creamery, the cans, etc., were rinsed with sterile milk exactly as had been done at the first establishment. Two deep setting cans, the strainer and several dippers were examined. Four of the separate quantities of contaminated milk became ropy. Two of them had been contaminated in the two deep setting cans and two in forty quart cans used on the route in delivering the dip milk. Cultures of the organism in question were obtained from all of the viscid samples except one, from a forty quart can. The milk rinsed in the dippers and that poured through the strainer did not become ropy. A quantity of sterile milk was inoculated with some of the water in use in the creamery, but the resulting changes did not indicate the presence of *Bacillus lactis viscosus* in the water. Had the results of Adametz's investigations been known to the writer at this time, a more extended examination would have been made of the water supply in both creameries.

The study of the conditions prevailing in the two creameries and the two dairies, indicated that a more thorough scalding of utensils would afford relief. It was suggested that the smaller utensils be totally immersed in boiling water for three minutes and that the larger cans be filled to the brim with boiling water for a like length of time. The suggestion was adopted and immediately brought the trouble to an end.

There were certain features connected with the outbreak which cast about it a shadow of mystery and discouraged efforts to locate the source. The two dealers consulted had purchased milk from all of the available dairies in the vicinity in an effort to supply the customers with faultless milk. Their lack of success is not surprising considering that the milk was dealt out from infected cans. From the standpoint of the consumer, the apparent wide distribution of the fault among the several dealers of the community was discouraging. A repetition of the occurrence of ropiness in milk obtained from any one dealer, generally caused the customer to patronize a rival dealer. Very frequently the change failed to prevent a recurrence of the trouble in the customer's milk vessel. Once infected, the milk pail or cream pitcher may harbor *Bacillus lactis viscosus* indefinitely, since thorough scalding is not a prominent feature in kitchen dish washing. Undoubtedly in this and in many other cases of a similar nature the consumer has unintentionally wrought great injustice upon innocent dealers by too hastily condemning the milk furnished when the true cause was careless dish washing. The importance of scalding vessels which have once contained ropy milk or cream cannot be too strongly emphasized.

The source from which *Bacillus lactis viscosus* originally reached the milk cans in the outbreaks studied is not known. Adametz has shown that its natural habitat in Austria is water. Assuming that the same is true in America, there is every reason to believe that ropiness in milk caused by *Bacillus lactis viscosus* can be prevented. Whether these particular bacteria are conveyed from brook water to the milk through the agency of the cows' udders, or directly to the milk utensils by the water used in washing them, proper precautions should prevent trouble from those sources. Where the trouble occurs, particular care should be taken to avoid the use of unboiled water for cleaning utensils and to prevent the cows from wading in water.

It seems highly probable that ropiness would not appear in milk handled in *sterile utensils* and consumed within 24 hours. The evidence at hand indicates that ropiness becomes troublesome in establishments handling milk, only when it is allowed to stand for some time, as in butter making. Milk, when drawn with ordinary precautions, contains a considerable number of species and among them may occasionally be found the one in question or others capable of producing ropiness. The low temperature at which milk is kept in the deep setting process of creaming is unfavorable to the multiplication of most of the bacteria commonly present in milk, but does not entirely check the growth of *Bacillus lactis viscosus.* Owing to the unusual faculty of growing at a low temperature, that bacillus, or any other possessing that faculty, might readily come to predominate even when originally introduced in small numbers. The imperfect cleansing of infected cans, together with their indiscriminate use for containing the market milk and the cream, results in the spread of the infection through all of the utensils in the establishment and to those of the consumer as well. In creameries where butter is made and milk is also sold, exceedingly great care must be taken in scalding utensils used for creaming.

In an outbreak of ropy milk in Michigan, Marshall concluded that the bacteria* fell into the milk from the udder during milking. Unfortunately the organism described by Marshall cannot be positively identified from the brief description available but there is reason to suspect its identity with *Bacillus lactis viscosus.* The results of Marshall's investigations indicate that extreme care in milking is of especial importance in preventing trouble from ropy milk. A discusssion of the general precautions which should always be taken to prevent the contamination of milk by bacteria cannot be given here, nor is it necessary. For definite instructions concerning general precautions to be taken in the stable, irrespective of the presence of trouble, the reader is advised to read a bulletin† on the care of milk which will be mailed free on application to the Secretary of Agriculture at Washington.

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* Bulletin No. 140, Michigan State Agricultural College Experiment Station.

When it is desired to determine which of several dairies supplying a creamery is furnishing the faulty milk, it may be a valuable aid to set samples of the milk of each dairy in separate vessels and note the subsequent changes, but in order that such a test may give reliable information and the conclusions work no injustice, several precautions must be observed.

1. The vessel used to contain the samples should be provided with a cover of some sort. Either a small fruit can or a bottle is convenient.
2. Both the can and cover must be thoroughly sterilized by steam or hot water and kept covered to exclude dust except when the contents are examined.
3. The sample must be poured directly from the patron's can without coming in contact with any other vessels whatever.
4. A fine wire with a loop bent at one end is the most convenient instrument to introduce into the vessel when determining the viscidness of the cream, but the loop must be heated to redness in a flame each time before it is used. The last precaution, one of the most important, is necessary in order to prevent transferring ropy milk from one vessel to another should it be present in any.

SUMMARY.

Ropiness is a fault of milk which does not necessarily depend for its cause upon the health of the cows. It is said to be caused by any one of several different species of bacteria. I have found *Bacillus lactis viscosus* to be the cause of viscid milk in two different creameries. In the two outbreaks investigated, the trouble was found to be caused by the use of milk utensils which had not been sufficiently scalded. The bacteria, remaining in cans which had previously contained viscid milk, were able to survive the washing and remain alive to infect new quantities of milk. Greater care in scalding utensils brought the trouble to an end. All small utensils were immersed in boiling water for three minutes and the larger cans were filled to the brim with scalding water which was allowed to remain for the same length of time. A thorough investigation of the sources from which the bacteria might have entered the milk at the stables and of sources elsewhere, failed to reveal the presence of *Bacillus lactis viscosus*. Nevertheless, from the work of Adametz, there is reason to suspect that during warm weather these particular bacteria get into the milk from water.

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†Care of Milk on the Farm, by R. A. Pearson. Farmers' Bulletin No. 63, U. S. Department of Agriculture.

The importance of thorough scalding of vessels which have once contained ropy milk is urged upon the consumer as well as the dealer. Bacteria may readily be transferred from running water to milk by the agency of mud, which drying upon the udder, may be dislodged during milking. Milk utensils which have been used for containing water, should be scalded before using again for milk. The apparent purity of water used about a creamery gives no assurance that it is free from bacteria.

DESCRIPTION OF A BACILLUS PROBABLY IDENTICAL WITH *Bacillus lactis viscosus* ADAMETZ, 1889.

Source.—Ropy milk from two creameries in New York State.

Morphology.—This organism is rod shaped in form with rounded ends and possesses a capsule. Owing to its relative shortness it may, upon superficial examination, be mistaken for a micrococcus. The individuals occur singly, in pairs placed end to end, and occasionally in chains. Apparently because of the viscid nature of the capsule, cover-glass preparations show a tendency for the organism to associate in groups of varying size. The paired arrangement is most commonly met with. In young cultures especially where active multiplication is taking place the individuals are either spherical in form or short rods exhibiting the various stages of segmentation.

There is a great variation in size depending upon the medium and age of the culture. In an agar slant eight days old the spherical forms vary from .6 to .8 μ. in diameter, while the elongated forms which predominate in numbers vary from 8. to 1.2 μ. in breadth and from 1.2 to 2 μ. in length. In a bouillon culture three days old great variation in size occurs, the predominating form measuring 1 to 2 μ. in breadth and from 2 to 3 μ. in length.

In all old cultures forms occur which differ widely from those in growing cultures. Involution forms, approximately circular in outline and measuring from 2 to 3 μ. in diameter, may appear singly or in pairs. Rods measuring about 1.2 μ. in width and from 2 to 4 μ. in length are occasionally present. Long chains are frequently found in cultures three weeks old. Some thread like forms occur which show no indication of division into separate individuals.

The organism stains readily with the aniline dyes in common use. It exhibits an irregular arrangement of the cellular protoplasm when stained with carbol fuchsin. This feature is more or less noticeable in individuals from all of the culture media, but is most conspicuous in bouillon (See plate). When treated by the Gram method the stain is retained. The capsule does not stain when treated by the common methods, but preparations made from milk by extracting the fat with ether and staining with carbol fuchsin show the capsule especially well as an unstained area surrounding each individual. The presence of the capsules can be positively demonstrated by Welch's glacial acetic acid method and by the Gram method.

The organism probably possesses slight motility, but the motion is so feeble that it is with difficulty distinguished from the Brownian movement. Motility is best observed in young milk cultures. The viscid nature of the growth presents difficulties which may have prevented the demonstration of flagella. In view of the uncertainty concerning the presence of motility this is unfortunate.

Biologic characters.—This bacillus is a strict aërobe. It grows readily in the presence of air upon all of the ordinary culture media. The minimum temperature at which growth will occur, is below 46° F. (8° C.) and the maximum, at about 104° F. (40° C.) A freshly inoculated milk culture was frozen for twenty hours without destroying its vitality. The cultures which are described below were all grown at room temperature.

Agar.—Growth appears in agar plate cultures in twenty-four hours after inoculation as circular gray colonies 1 to 2 mm. in diameter. Young colonies are opalescent and exhibit the phenomonon of diffraction of light. Mature colonies may be irregular in contour, flat, with sharply defined borders, and grayish white in color. Under low magnification no distinctive marking is apparent. The growth is viscid so that the substance of the colony adheres to the platinum needle and spins out into a fine thread. After several weeks, when the culture media has dried perceptibly, the viscid character tends to disappear, the colony becoming more pasty in consistency. In such old cultures, faint concentric markings are visible near the border.

The young growth upon the surface of slanted agar is opalescent and usually consists of numerous small confluent colonies. Later, when the growth thickens, the opalescent appearance is not noticeable. The condensation water becomes cloudy, viscid, and after considerable evaporation has occurred, brown in color. Growth in slant cultures of glycerine agar presents no distinctive features.

Fifteen per cent gelatin.—Surface colonies appear first as minute gray points upon the surface of the medium. Under a low magnification they are granular and show concentric, circular markings. Older colonies are approximately circular with a sharply defined border, and distinct circular markings. Some have a pronounced central protuberance surrounded by a thinner border, while others consist of a hemispherical mass alone. The colonies, at first whitish in color and opalescent, later become distinctly yellow. The growth is viscid like that of agar, but upon drying somewhat, the colony adheres to the platinum needle and becomes detached from the surface of the medium. The gelatin is not liquefied even after long standing. In ten per cent gelatin the growth is more luxuriant. Sub surface colonies appear as small whitish points. Gelatin stab cultures exhibit a white growth extending along the line of puncture. This is composed of minute, closely set whitish colonies, and is more vigorous near the surface. The surface growth in stab cultures presents no important features.

Bouillon.—In twenty-four hours after inoculation alkaline bouillon becomes slightly clouded and somewhat viscid. A thin gray growth adheres to the sides of the tube at the surface of the liquid, and if the culture is allowed to stand undisturbed, a thick extremely viscid pellicle forms after about a week. It extends gradually from the outer border of the surface towards the center. Upon displacing the pellicle, the liquid underneath is found to be much less viscid. When the culture is agitated daily, the pellicle does not form and the liquid becomes uniformly viscid throughout. A quantity of white, tenacious sediment is deposited. The reaction is alkaline constantly. Cultures a month old or more are extremely turbid, slightly yellowish in color, and contain considerable whitish viscid sediment. The growth is as vigorous in acid boullion as in the above and the reaction becomes alkaline in two days or less.

One per cent solution of sugars in bouillon contained in fermentation tubes.—In glucose, lactose, and saccharose bouillon growth occurs only in the bulb and the constricted U shaped portion leading to the closed arm. In each one the growth is discontinued abruptly at the base of the closed arm, showing the organism to be an obligate aërobe. The reaction in each is alkaline to litmus. Gas is not formed in any of the cultures.

Potato.—Twenty-four hours after inoculation a thin growth appears, which is distinguished with difficulty, being of the same color as the potato. Later, the growth becomes more abundant and viscid, assuming a drab color.

Blood serum, slanted.—The growth first appears as a yellowish, viscid mass occupying the line of inoculation, and eventually spreads over the moist portions of the medium. In the upper portions of the slanted serum, where there is relatively less moisture, the spreading of the growth is more restricted. Treelike branches grow out and anastomose with one another forming a net work which covers the surface of the medium to a greater or less extent.

Milk.—The cream on the surface of milk becomes noticeably viscid in twelve hours after inoculation. The milk below, while plainly ropy in young cultures, does not exhibit the maximum viscosity until several weeks have elapsed. In old cultures the milk will spin out in opalescent, gossamer-like threads frequently a yard long. If one of these fine threads be allowed to come in contact with a cover-glass and be examined microscopically, the milk will be found swarming with bacteria arranged in long chains. Only after considerable evaporation has occurred do milk cultures assume a semi-fluid consistency. The reaction, at first alkaline to litmus, becomes feebly acid after about two months.

In separator skim milk, additional appearances become apparent, due probably to the relatively smaller per cent of fat present. The milk promptly becomes viscid like whole milk, and remains so during the succeeding changes. After about a month the liquid gradually becomes translucent and opalescent throughout. This appearance, together with the alkaline reaction and the entire absence of fat globules, shown upon microscopic examination, indicates that saponification has occurred. In some cultures this change has been observed to occur first at the surface and later to extend downwards in a gradually broadening zone. A relatively large deposit of white precipitate occurs.

Indol.—An indol reaction is doubtful.

Thermal Death Point.—Freshly inoculated bouillon cultures remain sterile after exposure to a temperature of 58° C. for ten minutes. Exposure for the same length of time to a temperature one degree less, fails to kill the organism.

Disinfectants.—Duplicate tests conducted during the month of October show that a drop of buillon culture dried upon a cover-glass is rendered sterile by exposure to direct sunlight for three hours. Experiments conducted during January show that seven hours are required to accomplish the same result in mid-winter. Bacteria from a bouillon culture dried upon cover-glasses, have retained their vitality for a month when kept in the dark.

Experiments with a solution of powdered soap widely used in creameries do not indicate that that substance possesses disinfecting powers in the strength ordinarily used in dish washing.

Sufficient c. p. sulphuric acid was added to a four weeks old bouillon culture to make a five per cent solution. Inoculations in bouillon from this mixture after a lapse of one minute and after longer intervals, indicated by their failure to show growth, that five per cent sulphuric acid is rapidly fatal to *Bacillus lactis viscosus*.

ACKNOWLEDGMENT.

The thanks of the Dairy Division are extended to Dr. James Law, Director of the New York State Veterinary College and to Dr. V. A. Moore, Professor of Pathology and Bacteriology for the privileges of the Laboratories of Bacteriology in that college. I am personally indebted to Professor Moore and to Instructor R. C. Reed for many helpful suggestions which they have given during the prosecution of this work. The assistance rendered by Mr. Michael Quigley, Inspector of the State Department of Agriculture, and the hearty coöperation of the owners of the creameries in which the trouble occurred, were highly appreciated.

THE FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION TO THOSE WHO MAY DESIRE THEM.

40 Removing Tassels from Corn, 9 pp.
41 Steam and Hot-Water for Heating Greenhouses. 26 pages.
49 Sundry Investigations of 1892, 56 pp.
53 Œdema of the Tomato, 34 pp.
55 Greenhouse Notes, 31 pp.
61 Sundry Investigations of the Year 1893, 54 pp.
64 On Certain Grass-Eating Insects, 58 pp.
69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
73 Leaf Curl and Plum Pockets, 40 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N.Y., 116 pp.
77 The Grafting of Grapes, 22 pp.
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
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Bulletins Issued Since the Close of the Fiscal Year June 30, 1898

150. Tuberculosis in Cattle and its Control.
151. Gravity or Dilution Separators.
152. Studies in Milk Secretion.
153. Impressions of Fruit-Growing Industries.
154. Table for Computing Rations for Farm Animals.
155. Second Report on the San José Scale.
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157. Grape-vine Flea-beetle.
158. Source of Gas and Taint Producing Bacteria in Cheese Curd.
159. An Effort to Help the Farmer.
160. Hints on Rural School Grounds.
161. Annual Flowers.
162. The Period of Gestation in Cows.
163. Three Important Fungous Diseases of the Sugar Beet.
164. Peach Leaf-Curl.
165. Ropiness in Milk and Cream.

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Bulletin 166. **March, 1899.**

Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

AGRICULTURAL AND CHEMICAL DIVISIONS

Sugar Beet Investigations for 1898

This picture is from a photograph of the experimental beet plats on the Cornell University farm, taken October, 1898.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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CORNELL UNIVERSITY, ITHACA, Feb. 18, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir:—This bulletin, the second on sugar beet culture is published under Chapt. 68 Laws of 1898.

Part I has been written by Mr. John L. Stone, Part II, by Mr. L. A. Clinton, and Part III, by Mr. G. W. Cavanaugh and Mr. A. L. Knisely.

Mr. Stone has been in charge of the field experiments in the 15 counties which by mutual agreement between the state station at Geneva and the Commissioner of Agriculture were assigned to the Cornell Station.

Part I discusses the lessons of 1898 as seen by careful and frequent inspection of the beets in the field. A comparison is made of hilly, stony and level lands with reference to beet culture. Influence of soil on beet production, seeding, depth of planting, early tillage, distance between rows, distance of plants in the row, early and late planting, influence of preceding crop are all discussed and conclusions drawn from the facts secured by observing the plants while growing, and by weighing, measuring and analyzing the crop.

Fungous and insect enemies of the beet are discussed briefly. For a full report of three important fungous diseases of the sugar beet "Root Rot," "Leaf Spot" and "Beet Scab," see Bulletin 163, by B. M. Duggar, which is really a supplemental report of the investigations in beet culture made during the year.

The lessons learned while present when many fields of beets were being harvested are set forth, and the quality, yield of beets per acre, and the cost per acre of the growing and the cost per ton are fully tabulated.

The influence of fertilizers on yield and quality and the influence of variety on quantity and quality are fully noted.

It is found that the farmer himself is the greatest single factor in the profitable production of beets, therefore something has been said along this line.

Part II contains a brief statement of the investigations conducted on the University farm, and which to be at all reliable required daily personal attention.

Comparatively small areas were used that the variation of soil conditions might be eliminated so far as possible.

The land has a well known history for the last five years, and had been thoroughly mixed by artificial means and then separated into small plats of four by five feet, each plat separated from the others by means of water tight walls which extend to a depth of more than two feet.

The investigations were along six principal lines as follows :

1. Effects of thin and thick planting.
2. Effects of moderate and extra tillage.
3. Effects of thinning at various periods.
4. Effects of subsoiling.
5. Variety tests.
6. Fertilizer tests.

Part III contains a brief account of the chemical work. In addition to the 496 analyses of beets, several analyses of soil upon which beets were grown and samples of fertilizers used have also been made.

The average sugar content in the juice in 1898 was 15.29 per cent ; purity 83.6 ; in 1897, 16.91 per cent ; purity 83.5 and sugar in the beet 14.53 per cent, and 16.06 per cent for the two years, respectively.

Comparisons are made of the sugar in beets grown on sandy loam and clay loam soils. There is also appended tables showing the weather conditions and precipitation for 1897 and 1898 which are valuable.

The past season was peculiar in many respects. Unusual precipitation occurred in many localities about planting time and this was followed by severe drought when the beets were nearly half grown, and this in turn was followed by abnormal conditions at harvest time. The precipitation in October was 1.5 inches and temperature 2.8° above the average. Harvest was delayed and many beets were not gathered until November when the conditions were made still more difficult by continued abnormal precipitation.

The Secretary of Agriculture, Hon. James Wilson, the Commissioner of Agriculture, Chas. A. Weiting, Dr. H. W. Wiley, of Washington, and Dr. W. H. Jordan, Director of the State Experiment Station, Mr. J. E. Rogers, President of the Binghamton Beet Sugar Co., and many earnest farmers have all given valuable assistance in the extended work carried on during the year.

I. P. ROBERTS,
Director.

OBSERVATIONS AND CONCLUSIONS

BASED UPON A STUDY OF FIELD CONDITIONS.

BY J. L. STONE.

The investigations in sugar beet culture, carried on by this Station in 1897 seemed to give quite decided indications that there was much land in the state that could grow large crops of beets and that the beets would be of a quality highly satisfactory to the manufacturer.

No data were obtained as to the cost of growing the crop. It was well understood that a majority of the lands which seemed suited to sugar beets were in the hands of farmers who were accustomed to work three horses abreast attached to heavy machinery designed to turn off a large amount of work in a short time. The sugar beet is an exacting crop and requires a considerable amount of close, careful tillage necessarily somewhat slow and tedious. In fact sugar beet growing may more properly be classed as gardening rather than as farming. In view of these facts the question arose very distinctly. "Will these farmers develop the patience and skill of the gardener quickly enough to enable them to grow sugar beets at a profit before they shall become discouraged on account of the failures that many of them are sure to make?"

Therefore, the work of 1898 was planned with a view, not only of duplicating last seasons investigations, but of ascertaining what it cost different growers for the labor employed in securing their crops.

In accordance with arrangements made with the State Department of Agriculture at Albany, and the N. Y. State Experiment Station at Geneva, the Cornell University Agricultural Experiment Station conducted experiments with sugar beets, in 1898 in the following counties: Niagara, Orleans, Monroe, Genesee, Livingston, Wyoming, Erie, Chautauqua, Cattaraugus, Allegany, Steuben, Chemung, Tompkins, Tioga and Broome.

In these counties 1,113 lbs. of sugar beet seed were distributed to 417 farmers, and 21 one-pound lots were distributed to applicants outside these counties. Thus 438 farmers were connected with the work and 1,134 lbs. of seed were distributed. The larger part of these farmers received one pound each of seed, the object being to observe in a general way the growing of the beets on the different farms and to ascertain the percentage of sugar in the different samples. Thus far the work was a duplication of that of last year.

With about 125 farmers arrangements were made to grow plats of one-half acre or more, keeping a careful record of all the labor bestowed upon them. Instructions in regard to growing the beets were given in circular No. 15, which was accompanied by a blank for keeping the records. Many of the farmers were supplied with several varieties of seed for the purpose of making a variety test. About 40 of them received sacks of fertilizer for a fertilizer test. A representative of the Station visited nearly all of these plats during the season and some of them that were easily accessible were inspected frequently.

Later in the season Circular No. 17, was issued giving instructions in regard to harvesting, ascertaining yield and sending samples for analysis.

The small number of complete reports that have been received from the farmers growing these beets is somewhat disappointing. Some of the crops were complete or partial failures. This was due to a variety of causes operating in different cases, but though they were failures as crops they were instructive as experiments.

In more cases the farmers at some time during the season lost track of the labor account and were unable to report cost. In still other cases the farmers being pressed with work at harvest time, owing to the unfavorable weather conditions, failed to get as accurate records of yield as are necessary that their reports should be of greatest value. Still we have many valuable reports and the season's work as a whole is very instructive.

In the report of last year (Bulletin 143, pp. 493-517) were given "General Remarks on Sugar Beet Cultivation." The suggestions there made are sustained by this season's experience. Some points need to be further emphasized while others may be modified to suit the condition of particular cases. It is proposed to call attention to such lessons as have become apparent by a careful inspection and study of the experimental areas as well as many fields of beets grown for the factories.

The Binghamton Beet Sugar Co., Binghamton, N. Y., planned and carried out a very complete system of inspection and records of the fields of beets grown under contract for their factory. These records, through the courtesy of the company, have been open to the inspection of representatives of this Station and have furnished part of the data upon which are based many of the conclusions stated in this bulletin.

LESSONS FROM THE 1898 SUGAR BEET FIELDS.

Hilly land.—It is not wise to attempt to grow beets on hilly land. The seed-bed must be thoroughly fined ; the plants start rather slowly and it is some time before they afford much protection to the soil. In the meantime heavy rains are likely to occur and serious damage will result from washing. Some fields were reworked and planted to other crops and others were partial failures from this cause the past season. The crop on the University farm was materially injured in this way.

Stony land.—Avoid stony land. The beets require close cultivation, and small stones interfere with this and increase the expense. Nevertheless some very satisfactory crops, both as to yield and cost, were grown on land that when inspected by the Station representative was noted as "too stony for beets." These farmers knew their soil and were somewhat experienced in growing similar crops, and their skill enabled them to secure better results than were obtained by some others on far more favorable land. The credit is to the farmer and not to the soil.

Kind of soil.—The heavier grades of soil seem to have been more favorable in 1898 than the lighter ones. The drought of this year came in July and though not of long duration, on account of the intense heat and high winds, was severe. The beets evidently had not yet thrust their roots very deeply into the soil, and those on light land were greatly damaged. Those on heavier soils seemed to suffer less and recovered more completely when the rains came. The drought of 1897 came later in the season, and although much more prolonged and apparently more severe, the beets were not so much affected by it, and those on light soils seemed not to suffer more than those on the heavy.

Preparation of the land.—In no one way did farmers make mistakes that cost them so heavily in expense of tillage or yield of crop as by failure to properly prepare the land. On some lands subsoiling is desirable ; on all lands deep plowing and thorough fitting are necessary for satisfactory results. Land well prepared is more than half tilled. It is believed that more fall plowing should be done. Heavy land is especially benefitted by fall plowing. If this can be done early enough to get a start of crimson clover or rye as a cover crop, so much the better, only do not make the mistake of deferring the spring plowing till the cover crop has made large growth. Should dry weather come on soon after seeding, any considerable amount of coarse material turned under would so interfere with the rise of water from below into the surface soil as to hinder germination and growth.

Seeding.—Most growers used from 12 to 15 lbs. of seed per acre in 1898, and there is a great variety of opinions among them as to what is the proper amount. Where the conditions were favorable for germination the beets came up many times too thick, and some of the farmers propose to reduce the amount of seed used, partly to save expense, but more especially to save the labor of thinning. Where the conditions were unfavorable to germination an uneven stand was secured and some of these farmers propose to use 20 to 25 lbs. of seed per acre to secure a stand. It is believed that both of these extremes are unwise. If the conditions are so unfavorable that 15 lbs. do not give a stand, it is doubtful if 25 lbs. will produce the desired result. On the other hand, while three or four pounds would be abundant if nearly all of it grew, and the labor of thinning would be materially reduced, still it is unsafe to risk getting a stand from so small an amount of seed. Twelve to fifteen pounds of seed per acre are still recommended.

Depth of planting.—In some cases too deep planting resulted in a failure to get a stand. Early in the season, while the soil is cool and moist, deep planting should especially be avoided. One-half inch at this time is deep enough. It is well to have a narrow press-wheel follow the seeder and firm the soil directly over the seed while leaving the rest of the surface loose. Heavy showers soon after planting, followed by sunshine will often cause a crust to form that the young plants cannot break through. The alert farmer should discover this condition and break up this crust with a weeder, or some similar tool, before serious damage has resulted.

Early tillage.—A serious mistake was made by many growers by deferring the first working of the soil till the plants had attained considerable size and strength. As soon as the rows can be followed a hand cultivator (or lacking this a hand hoe) should be used to loosen the soil near the plants and check any weeds that may be attempting to gain a foothold. Again, some failed to do the thinning till the plants were too large. Not only were the plants injured by the removal of those taken out, but the labor involved in thinning these overgrown beets is several times what it would be if the work were done at the right time. Bunch the plants with a narrow hoe when they are from one-half inch to one and a half inches high, and thin them to one in a place when they are two to three inches high. Frequent light tillage is the secret of economically keeping ahead of the weeds, but as a rule beets receiving horse culture made better growth than those receiving hand culture only. The deeper tillage seems to be favorable for best results.

Distance between rows.—It is not necessary that the rows shall be more than 20 inches apart to allow of thorough horse culture. Still many farmers found difficulty in tilling rows of this width with the equipment and skill at their command. To such it is recommended that the distance between rows be increased for a season or two till they have acquired more experience and skill with the crop. It is confidently believed that they will return to the closer planting after a few seasons' experience. See p. 441

Early and late planting.—The advantage of early or late planting depends very much upon the character of the weather that follows, which of course cannot be foreseen. The past season the late planting gave the best average stands, and as it was thought that there was plenty of time to make sufficient growth the late planting was looked upon with favor. These fields had a very promising appearance during August and September and were kept free from weeds with less labor than the earlier plantings. However, at harvest time it was found that many of them had not made satisfactory growth and were not sufficiently matured to produce beets of high quality. As a result of the season's observations it is recommended to plant as early in May as the soil becomes warm and in thoroughly good condition. When careful farmers think the soil fit for corn planting, then the beet seed should be put in.

Effect of the preceding crop.—With a great number of varying conditions affecting the growth of the crop, it is, perhaps, unwise to attempt to ascribe a definite result to the influence of the preceding crop. It is only when large numbers of cases can be compared that this is permissible. From a study of the records of the Binghamton Beet Sugar Co. we discover that in 294 cases where both the previous crop and the yield per acre are given, the beets obtained were in the following order and relations, counting the largest average yield at 100.

INFLUENCE OF THE PRECEDING CROP ON THE YIELD OF BEETS.

	Preceding crop.	No. of cases.	Relative yields.
1.	Cabbage	32	100
2.	Clover sod	25	82
3.	Sod, other than clover	25	78
4.	Potatoes	100	73
5.	Corn	100	66
6.	Buckwheat	12	64

In seems from the above figures that cabbage is a crop especially desirable to precede a crop of beets. This probably is owing to several considerations. First, manure is usually applied freely for the cabbage crop and the land is left more fertile than after most other crops. Second, the thorough and late tillage required by the cabbage are particularly beneficial in preparing the land for a succeeding crop, and third, the farmer who has learned to successfully grow cabbage is already well on the road to successful sugar beet culture. True, there is little of the slow tedious work in cabbage growing that is often necessary in beet culture, yet the cabbage grower has very well learned the importance of thorough preparation of the land and thorough tillage.

It has been quite generally advised in the past not to grow beets on sod ground. But the experience of the last two seasons leads to the conclusion that sod, both clover and other, makes desirable beet land in New York. Unusual care, however, must be taken in the preparation of sod land for beets. It should be plowed early, the autumn or summer before is preferable, and very thoroughly fitted. If plowed late, the interposition of the inverted sod between the subsoil and the seed bed will prevent the free rise of moisture for a time, and should dry weather follow planting, germination and growth will be much retarded. Almost total failures clearly attributable to this cause were observed the past season. It will be observed that among the crops noted, buckwheat seems to be the least desirable to precede beets. It is not thought that the buckwheat itself is in any way harmful to the beet crop, but buckwheat is rarely planted on the best lands and it is assumed that the fertility of these fields is lower than that of fields that had been planted to other crops. In general it may be stated that the more exacting, as to fertility and tillage any crop is, the more desirable it is as a preparatory crop for beets.

Enemies of the beet crop.—In certain quarters, during the season, three species of insects were found preying upon the plants and the indications were that they might, under favorable conditions become destructive. So far as observed no considerable amount of damage was inflicted by any one of them during the past season.

The banded flea-beetle (*Systena taeniata*) was found quite abundantly at LeRoy and Darien in Genesee County, where it wrought some damage to several fields of beets. The blue-flea-beetle (*Systena hudsonias*) was found on the beet field at the University Farm, but did not appear in sufficient numbers to inflict serious damage. The beet-leaf miner (*Pegomyia vicina*) was observed in many fields, but in no case in sufficient numbers to result seriously. The entomological division has these pests and some others under close surveillance, and should they prove troublesome will no doubt be able to suggest methods of successful combat.

Three fungus diseases, root rot of beets (*Rhizoctonia Betæ* Kühn.), leaf spot of the beet (*Cercospora beticola* Sace.) and beet scab (*Ospora scables* Thaxter.),also made their appearance in sufficient abundance to attract attention, and in a number of cases to inflict considerable damage. These have received prompt attention by the Botanical Division and the result is embodied in Bulletin 163, to which the reader is referred for further information.

Harvesting the crop.—The labor involved in harvesting the crop of sugar beets seems to be greater than most farmers have anticipated. The excessive rains of the autumn, though they caused the roots to be lifted from the soil more easily, made it much more difficult to get them reasonably free from dirt, or to draw them from the fields, and added very much to the discomfort of the workmen while performing the somewhat tedious work of removing the tops and crowns. Better weather and more experience will no doubt permit the work to be done with greater despatch. It is suggested that a more general use of bushel crates in handling the beets will facilitate the labor.

Quality of the beets grown in 1898.—The beets analyzed in 1897 averaged 16.06 per cent of sugar in the beet and 83.5 per cent purity. In speaking of the high quality indicated by these figures, on page 496, Bulletin 143, it is stated: "It is known that some seasons are more favorable to a high quality of beets than others, and perhaps the past season, notably dry in August, September and October, produced beets of more than normal richness. It will not be surprising then if the high quality of beets secured this season is not maintained in the future with different weather conditions while the beets are maturing."

The season of 1898 was very different from that of 1897. Instead of being "notably dry in August, September and October," the precipitation during these months was very much above the normal (see p. 467). In some localities it was almost impossible to get on the land to take off the crop. It is not surprising then that the percentage of sugar in the beet is reduced to 14.53, a falling off of 1.53 per cent in sugar from last year. The purity remains practically the same (see p. 455). It may be assumed that we have experienced in these two years one of the most favorable and one of the most unfavorable seasons for quality of beets, and it is gratifying to note that the quality is maintained well above the minimum requirement for profitable manufacture.

Yield of beets per acre in 1898.—The number of reports received from farmers giving definite data in regard to yield per acre and the cost of growing the crop is very much smaller than was anticipated. From various causes, as explained elsewhere, they had at some time in the season lost track of the data and then the records were abandoned. Of the reports received forty-four give carefully ascertained yields from areas of one-fourth acre and upward, very few of them being less than one-half acre. From an examination of these forty-four reports the following is obtained:

Six report yields of less than 9 tons per acre.
Ten report yields of 9 or over but less than 11 tons per acre.
Four report yields of 11 or over, but less than 13 tons per acre.
Thirteen report yields of 13 or over, but less than 15 tons per acre.
Seven report yields of 15 or over, but less than 18 tons per acre.
And four report yields of over 18 tons per acre.

The smallest yield reported is 6.1 tons, the largest, 21.33 tons and the average, 12.98 tons per acre.

As to the character of the season—whether favorable or unfavorable—many more farmers pronounced it unfavorble than fair. Very wet early, it interferred with timely planting and securing a good stand. This was followed by very dry weather before the beets were thoroughly established and had sent their roots deep into the soil. A severe check to growth was experienced, and the operation of thinning resulted in damage to the plants that were left. When the late rains came they were so excessive that in some cases damage resulted. It would seem doubtful, therefore, if the past season should be rated as "fairly favorable."

From the field book of the Binghamton Beet Sugar Co. is taken the list of farmers appended below. Their names, post offices, area of beets grown and the yield per acre of trimmed beets obtained are given. These crops represent quite a large area, coming from about a dozen counties. Very many farmers did not do as well as these, but the list is so large and the area covered is so wide that it leaves no doubt but that most farmers may do as well when they shall have learned how to grow beets. None of these farmers have had previous experience in growing beets and it does not necessarily follow that they are more skillful than some others who did not succeed so well. True, the thorough, painstaking farmer is more likely to succeed at first than the careless, but until more experience is had with the crop much will depend upon a fortunate timing of the work and selection of land.

Yields Obtained by Some of the Farmers Growing Sugar Beets for Manufacture.

Name.	Post office.	Acres grown.	Yield per acre. Tons.
Adams, S. B.	Sherburne	2	10.8
Albertson, C.	Waverly	1	11.7
Ainsley, G. W.	Binghamton	1⅛	12.6
Armstrong, S. E.	Unadilla Forks	1	17.6
Babcock, C. L.	Fulton	1	20.5
Bascett, G. S.	Coopers	1	11.2
Beardsley, R. E.	Elmira	2	10.9
Becker, P.	Central Bridge	1	13.2
Bidleman, J. F.	Chemung	1¼	12.3
Bowman, W.	Baldwinsville	1	21.0
Boyce, P. H.	Corning	2	11.5
Branard, C. M.	Stockwell	1	16.7
Brand, Jno.	Elmira	2	21.3
Brown, A. W.	Unadilla Forks	2.5	14.8
Brown, G. A.	Pitcher	1	11.7
Brumsted, Chas.	Batavia	1	12.7
Buell, O. A.	Sherburne	1	12.5
Berry, H. W.	W. Winfield	1	10.3
Caple, P. J.	Cattatunk	3	13.8
Cardner, P. R.	Tulley	2	17.1
Carley, A. W.	Binghamton	1	13.4
Carpenter, G. F.	Lindley	1	12.6
Carr, F. J.	Tully	1	12.5
Carrier, E.	Corfu	1	13.5
Caccada, M. F.	Wells Mills	1	10.6
Chamberlain, E.	Southport	1	14.2
Chamberlain, Geo.	Elmira	2	10.9
Clark, E.	Tully	1	10.2
Clark, G. H.	Cooperstown	3	10.9
Colliere, F. J.	Preble	1	12.3
Corbett, M. J.	Corbettville	1	12.7

Crawford, E.	Milford	1.5	11.4
Cummings, C. J.	Tully	1	22.1
Cummings, O. J.	Preble	1	16.2
Curtin, D. E.	Tully	1	14.2
Daley, Frank	Preble	1	14.9
Darby, L. D.	Milford	1	12.9
Davadge, Jas.	Binghamton	6	12.1
Davison, Chas. S.	Elmira	3	12.4
Dietz, P. B.	Barnesville	2	10.9
Duglace, Geo.	Candor	2	13.7
Dunham, H. W.	Nichols	1	11.3
Edgecomb, G.	Waverly	1.5	14.7
Elmer, J. C.	Presho	1	15.9
Elmer, S.	Presho	1	14.1
Ellis, Spencer	Unadilla	1	11.3
Ensign, D.	Killawog	1	10.7
Evans, R. W.	Riverside	1	12.6
Fenderson, G. L.	Lounsberry	1	13.8
Foote, J.	Sherburne	1	11.7
Foster, Jas.	Sherburne	3	20.2
Fuller, D. L.	Corning	1	10.2
Gates, C. H.	Unadilla Forks	1.5	11.9
Gates, J. A.	Killawog	1.5	10.2
Gay, F. J.	Preble	1	15.9
Giddins & Son,	Baldwinsville	1	13.0
Groton, S. W.	Lavonia	4	10.1
Haley, M. H.	Waverly	1	19.9
Hall, Jno.	Homer	1	14.8
Hanson, A. B.	Windsor	3	12.4
Harden, Benj.	Southport	1	14.2
Harper, L. G.	Darien	1	14.9
Harrington, W. D.	Lowman	1	13.3
Harris, J. H.	Elmira	2	12.6
Hanen, A. G.	Sangerfield	1	14.6
Hazard, J. H.	Himrods	1	17.4
Hemsbrought, E.	Campville	1	11.6
Hedlerman, Thos.	E. Bethany	1	11.2
Hovey, C. C.	Bainbridge	1	11.9
Hoyt, S. T.	Corning	2	14.6
Jarvis, I. S.	Hartwich Line	1	10.3
Jones, Theo.	Baldwinsville	1	15.2
June, A. K.	Port Crane	1	14.9
Karkritz, Chas.	E. Corning	1	15.3
King & Long,	Tully	1	17.3
Knapp, A. A.	Preble	1	12.8
Knapp Bros.,	Deposit	1	12.1

Knapp, C. A.	Homer	2	12.0
Kneale, Chas.	Horseheads	1	10.2
Kuhl, R. V.	Lawrenceville, Pa	1	13.9
Lamb, W. G.	E. Harrington	1	21.6
Lane, Geo. S.	Lounsberry	1	15.1
Leaman, A.	Central Bridge	1	14.0
Littlewood, G. H.	Lisle	1.5	11.2
Lasee, R. R.	Laurens	1	15.9
Lowman, M.	Wellsburg	1	14.8
Martin, H. S.	Binghamton	3	11.6
McCauley & Smith,	Horseheads	2	12.3
McMurdy, W. J.	Binghamton	2	17.3
McNamara, T.	Sangerfield	1	16.6
McQueen, H. H.	Horseheads	1	17.4
Millers Bros.,	Elmira	5	17.6
Montague, C. D.	Campnelle	1	12.6
Oxie, W.	Homer	1	15.4
Murphy, J. C.	Horseheads	2	14.2
Nelson, H.	Pavillion Center	1	11.2
Newcomb, C. A.	Rathbone	1	24.0
Newcomb, J. H.	Addison	1	13.3
Nye, M. S.	Preble	1	13.4
Newton, C. O.	Hameb	4	13.8
Odell, G. D.	N. Birdgewater	1	12.4
Outt, S. D.	Preble	1	18.7
Park, A. D.	Osborne	3	16.8
Parkinson, T. W.	N. Bridgewater	1	15.6
Phoenix, L. J.	Addison	1	14.2
Plunkett, E. F.	Lindley	1	13.1
Powell, J. G.	Elmira	1	12.9
Pumpelly, G. N.	Owego	6	13.3
Quinn & Co.	Sherburne	5	10.9
Rackly, W. J.	Seely Creek	1	21.0
Randall, W. N.	N. Bridgewater	1	18.7
Rathbun, A. T.	Wellsburg	1	12.1
Riehlman, F.	Otisco	1	11.7
Risley, J. M.	Cassville	3	16.1
Roberts, W. C.	Windsor	1	13.5
Rood, W. C.	Center Lisle	1	11.3
Rowland, W. H.	Bridgewater	1	16.1
Ray, W. J.	Southport	2	14.4
Saunders, Henry	Horseheads	2	14.5
Shafer, Geo. A.	Cobleskill	2.25	13.2
Sherwood, H.	Addison	1	13.3
Smith, Chas.	Big Flats	2	11.4
Smith, J. J.	Candor	1	11.2

Smith, W. C.	Candor	1	14.2
Smith & Powell	Syracuse	15	15.3
Snell, F. W.	Chemung	1	18.1
Shrague, C. R.	Binghamton	1	11.0
Squires, H. C.	20 Cortland Street, N. Y.	2	11.6
Stage, Clarence	Wellsburg	3	13.8
Stebbins, H. D.	W. Winfield	1	16.0
Stermer, Jno.	Big Flats	1	19.4
Swart, C. S.	Cobleskill	2	13.0
Swartout, G. R.	Harwick Seminary	1	11.8
Taylor, N. D.	W. Winfield	2	13.9
Thomas, G. H.	Chenango Bridge	1	20.3
Thompson, D. G.	Corning	2	12.7
Tracy, Matt.	Tully	1	11.6
Treat, R. S.	Horseheads	1	22.6
Tuckerman, G.	Cassville	2	16.0
Treyon, F. C.	Peoria	1	14.6
Vanderburg, W. D.	Preble	1	11.1
Van Duser, J. S.	Horseheads	8	14.3
Vincent, G. S.	Scott	1	11.8
Van Housen C.	Tully	1	12.1
Waddell, C. R.	W. Winfield	1	12.1
Weed, J. B.	Binghamton	6	15.9
Wellman, A. E.	Covington	1.5	13.0
Wells, G. M.	Big Flats	2	11.4
Westlake, L. D.	Horseheads	1	15.6
Wilcox Bros.,	Horseheads	1	18.2
Williams Bros.,	W. Winfield	1	12.0
Wright, Robt.	Little York	2	14.7

These 152 farmers planted 252 acres of beets and harvested an average of 14 tons of trimmed beets per acre.

Cost of growing an acre of beets.—Arrangements were made with more than one hundred farmers to keep careful records of the number of hours of labor of teams, men or boys employed in growing their fields of beets. Blanks were furnished for keeping the data and making reports. They were instructed to charge up this labor at the usual price in their localities. Only forty-five reports complete in this respect have been received. The figures given do not include the cost of seed, fertilizer or the use of land. Of the 45 farmers

4 report the cost as less than $25 per acre.
6 report the cost as between $25 and $30 per acre.
12 report the cost as between $30 and $35 per acre.

7 report the cost as between $35 and $40 per acre.
3 report the cost as between $40 and $45 per acre.
1 reports the cost as between $45 and $50 per acre.
4 report the cost as between $50 and $55 per acre.
2 report the cost as between $55 and $60 per acre.
5 report the cost as over $60 per acre.

The lowest cost reported is $10.20 per acre, the highest $83.00 and the average, $38.15.

As was expected the range of cost per acre is very wide and is affected by many circumstances. It was attempted to observe these fields very carefully to determine if possible the conditions that contribute to excessive cost. Many of these conditions have already been referred to under their proper headings. Among others that remain to be mentioned attention is especially called to the necessity of timeliness in doing the work. This applies all through the season and to every operation, but especially to thinning and weeding during the early periods of growth. There is a time when these operations can be performed at the minimum of cost, and sometimes the delay of a week will double or even quadruple the expense of getting the crop in proper condition. Perhaps the highest skill of the grower is manifested by wise management in this respect.

Another mistake made by many was in tilling the crop by hand instead of horse labor. In nearly every case of excessive cost reported it is attributable to one or the other of these causes. As a result of this season's observations it is believed that when the farmers shall become experienced with the crop $30 to $40 per acre may be named as the probable range of cost.

From the field book of the Binghamton Beet Sugar Co. it is found that the 119 farmers who report the cost of growing the crop up to, but not including the harvest, place the average cost at $16.04 per acre. The cost of the harvest may be placed at $10 to $12 per acre and the total will still be below the minimum suggested above. This leads to the suspicion that only those who were successful in keeping the cost at a low figure reported this item.

Cost of beets per ton.—The cost per ton, depending as it does on both the cost and yield per acre, is affected by every condition influencing the crop during the season. A study of the reports brings to light some interesting features. Some of the highest costs per acre, leave a possible margin of profit because large crops were secured. The lowest cost per ton ($1.41) is associated with a low yield, (7.20 tons per acre) and is made possible by the exceedingly small amount of expense ($10.20), bestowed upon the crop.

Of the 43 reports in which cost per ton is given,

9 place the cost below $2.00 per ton.
15 place the cost between $2.00 and $3.00 per ton.
10 place the cost between $3.00 and $4.00 per ton.
5 place the cost between $4.00 and $5.00 per ton.
4 place the cost above $5.00 per ton.

The lowest cost is $1.41, the highest $7.52, and the average $3.25 per ton.

The high cost of $7.52 per ton is only possible by the association of high cost per acre with a small yield. The conditions that brought about this particular result are not likely to recur with experienced growers, nor are we likely to find many cases where an expenditure of only $10.20 per acre will produce any profit in sugar beet growing. More than half of these reports place the labor cost of a ton of beets at less than $3.00, but the average is drawn above that figure by a few cases of excessive cost.

Effect of fertilizer upon yield.—The Station supplied sacks of fertilizer to a number of farmers to be applied to a part of their experimental area. The sacks contained

58 pounds of dissolved rock guaranteed 14 per cent phosphoric acid.
40 pounds of sulfate of potash, guaranteed 50 per cent potash.
30 pounds of sulfate of ammonia guaranteed 20 per cent nitrogen.

Each lot of fertilizer was intended for a ¼ acre plat, or at the rate of 512 pounds of the mixture per acre, furnishing 24 lbs. of nitrogen, 32½ lbs. phosphoric acid and 80 lbs. of potash. While the effect of the fertilizer was very apparent during the growing period, producing a much more vigorous growth and in several instances resulting in a much better stand of plants, yet it is greatly regretted that only five growers took pains to harvest the fertilized and unfertilized plats separately so as to be able to report comparative yields. Some of these grew several varities of beets, so there were in all 13 plats fertilized and 13 plats unfertilized. The average yield of the fertilized plats was

12.84 tons per acre and of the unfertilized 9.37 tons—a gain of 3.47 tons per acre in favor of the fertilized plats. In some instances the gain was very much more marked than in others and was profitably secured. On the average the gain just about paid the cost of the fertilizer and the labor of handling the extra tonnage of beets. In the second and third columns of the following table is given the respective yields obtained from the fertilized and unfertilized plats :

INFLUENCE OF FERTILIZER UPON YIELD AND QUALITY OF BEETS.

(When several varieties were grown fertilized and not fertilized, the average of the fertilized and not fertilized plats is used.)

Name of Grower.	No of var.'es averaged.	Yield, tons per acre.		Sugar in beets, per cent.		Purity.	
		Fertilized.	Not Fertilized.	Fertilized.	Not Fertilzed.	Fertilized.	Not Fertilized.
D. H. McLallen, Trumansburg	4	10.95	7.59	15.31	14.51	84.4	82.7
C. E. Chapman, Peruville	3	18.61	11.81	16.98	15.03	86.7	83.3
C. D. Cartwright, Darien	3	12.43	10.17	17.50	16.59	86.1	86.5
L. R. Rogers, Albion	2	10.43	7.03	16.77	16.34	88.8	88.0
F. R. Thompson, Westfield	1	11.80	10.25	16.15	15.06	89.9	88.5
C. B. Kershaw, Owego	1			11.40	11.59	76.4	79.2
C. D. Jackson, Peruville	1			14.44	14.16	83.0	79.4
J. C. Murphy, Horseheads.	4			13.23	14.42	81.0	84.1
A. J. Howland, Ithaca	1			15.77	15.25	80.2	81.5
Average yield of 13 plats by 5 growers		12.84	9.37				
Gain in favor of fertilized plats		3.47					
Average per cent of sugar and purity of 20 plats by 9 growers				15.28	14.74	84.0	83.7

Influence of fertilizer upon quality of beets.—The table given above shows the effect produced by the fertilizer described under the last topic upon the per cent of sugar in the beets and the purity of the juice. Nine experiments gave 20 plats fertilized by the side of 20 plats unfertilized. The average per cent of sugar in the beets produced on the former was 15.28 and on the latter 14.74, a difference of .54 in favor of the fertilized plats. The average purity of the juices obtained from the former was 84 and from the latter 83.7, a difference of .3 in favor of the fertilized plats.

Influence of variety upon yields of beets.—A large number of farmers were supplied with several varieties of beet seed, but unfortunately very few of them harvested the varieties separately so as to be able to note comparative yields. The following table gives the yields obtained by six farmers with from two to four varieties each. It seems that there is comparatively little difference in the yielding quality of the varieties named.

INFLUENCE OF VARIETY UPON YIELD OF BEETS.

(When more than one plat of a variety were grown by the same person the average is used.)

Experimenter.	Tons per acre.			
	Klein-wanz-lebner.	Vilmorin.	Schreiber's German.	Zeringen.
D. H. McLallen, Trumansburg......	9.72	10.61	8.82	7.41
Wm. Heyward, Stafford....	8.46	8.31	8.81	9.71
C. E. Chapman, Peruville..........	13.04	14.47	18.13	
C. D. Cartwright, Darien............	12.38	10.28	11.25	
Miss E. R. Hall, West Perrysburg ..	16.55	14.37	13.50	
L. R. Rogers, Albion	9.13	8.33		
Averages of 6 cases, two varieties..	11.57	11.06		
Averages of 5 cases, three varieties	12.07	11.61	12.10	
Averages of 2 cases, four varieties..	9.09	9.10	8.81	8.56

Influence of variety upon quality of beets.—On p. 453—is given the averages of all the analyses made of several leading varities used in the experiments this season. It has been thought best to present here some of the results obtained where these varieties were planted side by side, all of the conditions except variety being the same.

INFLUENCE OF VARIETY UPON QUALITY OF BEETS.

(When more than one plat of a variety was grown by the same person the average is given.)

	Kleinwanzlebener.		Vilmorin.		Schreiber's German.		Zeringen.	
	Per ct. sugar in beets.	Purity.	Per ct. sugar in beets.	Purity.	Per ct. sugar in beets.	Purity.	Per ct. sugar in beets.	Purity.
D. H. McLallen, Trumansburg.	15.06	86.5	13.65	80.8	16.41	85.3	14.53	81.4
Miller Bros., Elmira...........	14.49	86.6	14.25	82.8	16.15	87.2	15.30	88.9
J. C. Murphy, horseheads.....	12.78	78.1	13.78	82.8	14.70	86.3	13.72	82.3
S. S. Cole, Cuba..............	14.35	80.8	15.39	86.2	15.77	87.4	15.20	87.9
E. G. Fenton, Fenton..........	14.35	87.3					15.53	87.9
C. E. Chapman, Peruville......	16.20	86.6	14.58	84.8	16.32	84.4		
C. D. Cartright, Darien........	16.84	85.4	16.60	85.0	17.69	88.5		
W. B. Kneebone, Franklinville	17.10	89.1	15.11	81.9	18.19	89.1		
J. Jenks, Le Roy..............	15.30	85.2	15.30	83.8	14.63	86.5		
E. R. Hall, W. Perrysburg....	16.06	82.8	16.72	86.7	17.10	90.0		
C. M. Lusk, Lisle..............	15.84	87.3	14.96	84.8	16.48	87.4		
S. A. Ingersoll, Owego........	13.97	85.0	14.25	83.8	13.78	84.3		
C. H. Andrews, Owego........	13.78	83.3	12.83	78.5	14.63	84.6		
G. E. Merill, Sheridan........	13.11	81.2	13.11	82.1				
Chas. Barlow, Le Roy.........	15.08	87.1	13.35	77.2				
N. Wheeler, Arkport..........	15.34	88.7	15.11	84.5				
L. R. Rogers, Albion.........	16.96	90.1	16.15	86.8				
Average of 16 plats.........	15.14	85.8	14.69	83.3				
Average of 12 plats.........	15.15	85.5	14.78	83.5	15.99	86.9		
Average of 5 plats..........	14.21	83.9					14.86	85.7
Average of 4 plats..........	14.17	83.0	14.27	83.1	15.76	86.5	14.69	85.1

We give below a list of the farmers who have carefully recorded the data relating to their crops and forwarded to us the reports upon which much of the foregoing is based. They have the thanks of the Station for their coöperation and the farmers of the state owe them a debt of appreciation. Many others grew crops that were instructive but some of the data was lacking and reports were not forwarded to the Station, or if forwarded were not sufficiently complete to be available for tabulation.

LIST OF FARMERS WHO FURNISHED DETAILED REPORTS ON THEIR SUGAR BEET CROPS.

ALLEGHANY CO.

Cole, S. S.	Cuba
Morgan, C. H.	Cuba

BROOME CO.

Hazzard, G. E.	Upper Lisle
Lusk, C. M.	Center Lisle
Mercereau, M. L.	Union
Witherill. Dr. L. D.	Union

CATTARAUGUS CO.

Clements, Geo.	Franklinville
Davies, Thos. H.	Fairview
Hall, Ellen R.	West Perrysburg
Kneebone, W. B.	Franklinville
Kales, J. W.	Franklinville

CHAUTAUQUA CO.

Fenner, M. M.	Fredonia
Thompson, T. R.	Westfield

CHEMUNG CO.

Murphy, J. C.	Horseheads

ERIE CO.

Fenton, E. G.	Fenton

GENESEE CO.

Barlow, Chas.	Le Roy
Cartwright, C. D.	Darien
Jinks, Jacob	Le Roy
Hayward, Wm.	Stafford
Stutterd, J. F.	Stafford
Tillotson, F. A.	Pavilion

LIVINGSTON CO.

Barber, Aaron	Avon
Caff, W. H.	Wadsworth
Jacobs, S. H.	Mt. Morris

MONROE CO.

Curtis, Chas. E.	Hilton
Demming, H. C.	So. Greece
Smith, I. W.	Hilton

NIAGARA CO.

Hinman, Edw.	Lockport

ONONDAGA CO.

Barnes, E. A.	Baldwinsville
Guereau, C. H.	Baldwinsville
Van Wie, Levin	Baldwinsville

ORLEANS CO.

Allis, Clark	Medina
Howell, H. B.	Medina
Morgan, B. F.	Albion
Phipps, H. E.	Eagle Harbor
Rogers, L. R.	Albion
Staines, Chas. F.	Albion
Wyley, W. S.	Albion

STEUBEN CO.

Graves, B. J.	Ingleside
Hayt, S. T.	Corning
Wheeler, N.	Arkport

TIOGA CO.

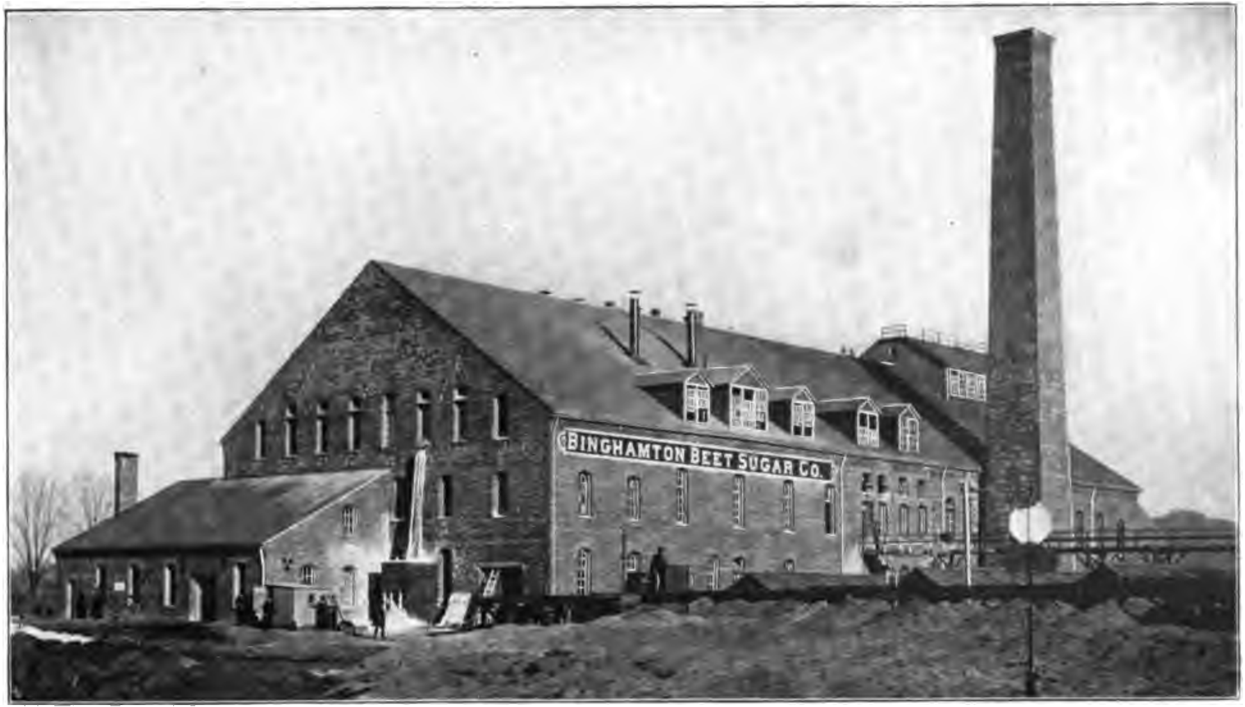
Goodrich, Stephen	Owego
Ingorsoll, Geo. A.	Nichols
Kershaw, C. B.	Owego

TOMPKINS CO.

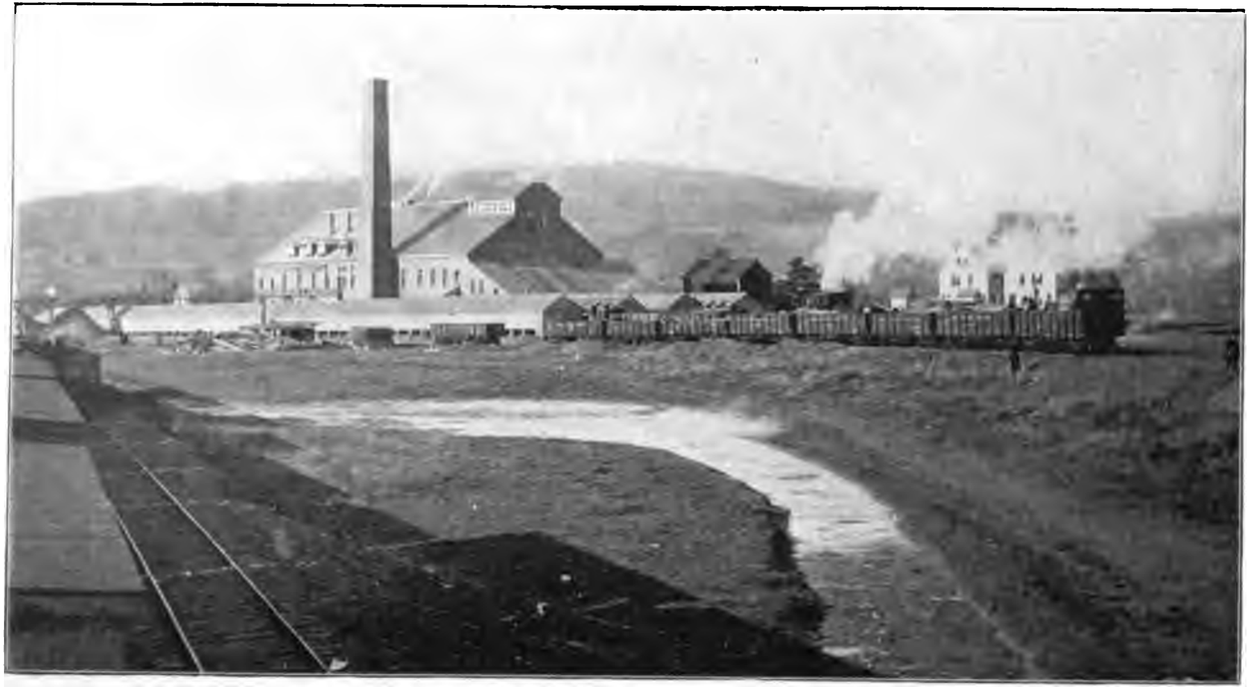
Chapman, C. E.	Peruville
Cornell University Farm	Ithaca
Howland, A. J.	Ithaca
Jackson, C. D.	Peruville
McLallen, D. H.	Trumansburg

WYOMING CO.

Matteson, Geo.	Orangeville
Treyon, F. C.	Peoria



73.—*Factory of the Binghamton Beet Sugar Co., Binghamton, N. Y. (Pile of beet pulp in the foreground.)*



74.—*The Binghamton Factory from the southwest.*

PART II.

EXPERIMENTS WITH SUGAR BEETS AT THE CORNELL UNIVERSITY EXPERIMENT FARM, 1898.

BY L. A. CLINTON.

In bulletin No. 143 of this Station was published results of fertilizer experiments with sugar beets in 1897. In 1898 it was decided to conduct in addition to the fertilizer experiments, investigations relating to the culture of beets. The following lines of investigation were decided upon :

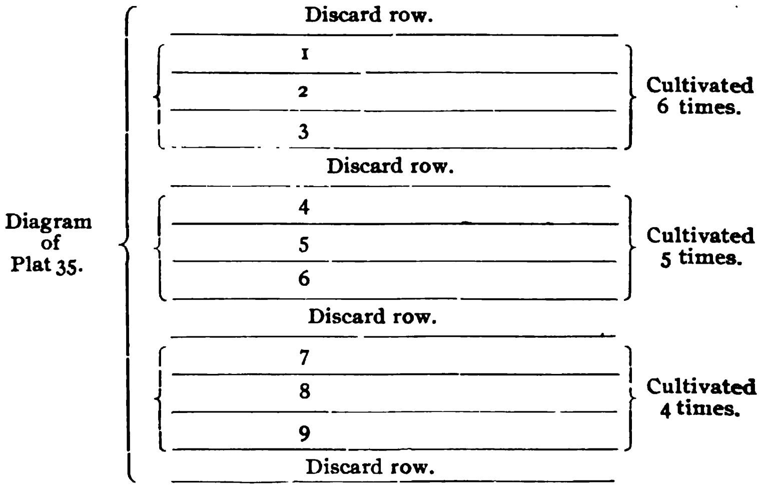
1. Rows 24 inches apart and beets thinned to 6 inches in the row compared with rows 20 inches apart and thinned to 9 inches in the row.
2. Effects of tillage.
3. Effect of bunching and thinning at various periods of growth.
4. Effect of subsoiling the land immediately previous to planting.
5. Test of varieties.

Wide Planting of Rows vs. Narrow Planting—It is generally recommended that beets be planted in rows 20 inches apart. Most farmers are not familiar with the methods of tillage required when rows are so planted. If the rows could be planted at a distance apart of 24 inches it would very much facilitate culture, especially until the farmers become familiar with intensive methods required in sugar beet production. Plats 33 and 34 of the permanent series of plats were selected for the work. These plats have for five years been heavily cropped and no fertilizer has been applied since the winter of 1893–4. The soil is gravelly loam and especially subject to effects of droughts. Land was plowed in the fall and replowed in the spring. The following table shows the results from the two plats :

Plat No.	Date planted.	Date thinned.	Dates cultivated.	Date harvested.	Yield per acre.
33, rows 20 inches apart.	May 11	June 1	June 1–6 17–24 July 12–28	Oct. 27	20 tons
34, rows 24 inches apart.	May 11	June 1	June 1–6 17–24 July 12–28	Oct. 27	18 tons

On plat 33 the beets were thinned in the row to distances of 9 inches, and on plat 34 the space left between beets in the row was 6 inches, thus securing approximately the same number of plants per plat. While in the early stages of growth the tillage of the rows which were 24 inches apart was somewhat simplified, yet on the whole the rows which were 20 inches apart were easier kept clean, and after becoming somewhat familiar with their cultivation no trouble was experienced. Where the land is in proper condition for sugar beet growing the rows should be not more than 20 inches apart. The table above shows that where rows were 20 inches apart the yield per acre was two tons more than where rows were 24 inches apart. All conditions were alike as nearly as they can be made in field culture, and the results were decidedly in favor of the close planting of rows.

Effect of tillage on beets.—Tillage has shown such marked results upon certain crops which have been experimented with that it was thought wise to determine if equally marked results could be obtained upon sugar beets. Plats 35 and 36 of the regular series were devoted to the work. Each plat was divided into three areas each of which would contain three rows of beets, each row being 109 feet long. The following diagram shows the arrangement of rows:



Plat 36 was a duplicate of 35.

The soil is fairly uniform on the two plats, and was given the same preparation. The variety of beets grown was the Kleinwanzlebener. The following table shows the number of cultures given the various areas and their results:

No. of plat.	Date planted.	Date thinned.	Date harvested.	Yield per acre. Tons.	Per ct. of solids in juice.	Per ct. of sugar in juice.	Per ct. Purity.	Per ct. of sugar in beet.
35 1st Division, 6 cultures.	May 11	June 2	Oct. 27	17.6	19	16.70	87.9	15.87
35 2nd Division, 5 cultures.	May 11	June 2	Oct. 27	23.6	19.5	16.95	86.9	16.10
35 3rd Division, 4 cultures.	May 11	June 2	Oct. 27	18.8	21.1	18.20	86.3	17.29

Following table shows the results obtained from a duplicate of the above experiment.

No. of plat.	Date planted.	Date thinned	Date harvested.	Yield per acre. Tons.	Per ct. of solids in juice.	Per ct. of sugar in juice.	Per ct. Purity.	Per ct. of sugar in beet.
36 1st Division, 6 cultures.	May 11	June 2	Oct. 27	14.8	20.9	18.25	87.3	17.34
36 2nd Division, 5 cultures.	May 11	June 2	Oct. 27	22	19.1	16.70	87.4	15.87
36 3rd Division, 4 cultures.	May 11	June 2	Oct. 27	18.8	19.5	16.20	83.1	15.39

Average yield per acre from 6 cultures, 16.2 tons.
Average yield per acre from 5 cultures, 22.8 tons.
Average yield per acre from 4 cultures, 18.8 tons.

The data given above are from experiments which are too limited to warrant our drawing conclusions as to the number of cultures best adapted to give good results with sugar beets. While in this experiment five cultures resulted in the largest yield yet it would be erroneous to draw the conclusion that five cultures would always give the best yield. The conditions as determined by soil, rainfall, previous treatment of land, etc., would all need to be considered. This experiment will be continued to learn if more definite data can be obtained.

Effect of bunching and thinning at various periods of growth.—It is usually recommended that beets be thinned at about the time the second pair of leaves appear. It is found in practice that it frequently is impossible to thin the beets at the time recommended. The experiment was undertaken to learn if it is important that beets be thinned at a certain time in their growth or if considerable range in time may be taken. The variety of beets grown was Kleinwanzlebener, and the plat selected was No. 39 of the permanent series of plats. The following table shows the results:

Plat No.	Date planted.	Date thinned.	No. of cultures.	Date harvested.	Yield per acre. Tons.	Per ct. of solids in juice.	Per ct. of sugar in juice.	Per ct. Purity	Per ct. of sugar in beet
39 1st Division	May 11	June 3	6	Oct. 28	22.3	19.5	16.80	86.1	15.96
39 2nd Division	May 11	June 10	6	Oct. 28	23	18.8	16.35	87.	15.53
39 3rd Division	May 11	June 17	6	Oct. 28	28	17.	14.35	84.4	13.63

A study of the above table shows that the yield per acre was considerably more where the thinning was delayed until the beets had made considerable growth. This indicates that where conditions are favorable considerable range may be taken as to time of thinning. With the weather cool and the soil moist thinning may safely be done when the beets have attained a height of three to four inches. However, thinning is such a slow process that it would better be commenced on time, viz., when the second pair of leaves appear the plants should at least be bunched. The bunches may then safely be allowed to remain for a week or ten days before the beets are thinned to a stand of one beet in a place. If one could always be certain that the weather would be cool and the soil moist then there would not be the imperative necessity for beginning thinning early. If thinning be delayed until there exists drought accompanied by hot weather the growth of the plants may be seriously impaired, if the plants are not entirely destroyed.

Effect of subsoiling immediately preceding planting.—In 1897 it was thought that subsoiling the land immediately preceding planting resulted injuriously to the growth of the beets. To determine the effect of subsoiling under the conditions which might prevail in 1898 plat No. 40 was selected as a suitable place for the test. Immediately before planting, one-half of the plat was subsoiled deeply, and the soil thoroughly loosened to a depth of about 15 inches. Seven rows of beets each 109 feet long and 20 inches apart were planted respectively upon the half of the plat subsoiled and upon the half not subsoiled. The result of the experiment is shown in the following table:

Plat 40.	Date planted.	Date thinned.	No. of cultures.	Date harvested.	Yield per acre. Tons.	Per ct. of solid in juice.	Per ct. of sugar in juice.	Per ct. Purity.	Per ct. of sugar in beet.
7 rows, not subsoiled...	May 11	June 5	6	Oct. 28	22.4	17.	14.35	84.4	13.63
7 rows subsoiled	May 11	June 5	6	Oct. 28	25.3	17.1	14.25	83.3	13.54

The seven rows which were subsoiled gave an increased yield of nearly three tons per acre. The good results following subsoiling were without doubt due in part to the fact that the soil was abundantly supplied with moisture during the early period of growth. Before the severe drought of July the subsoil had become sufficiently compacted so that capillarity was restored and the plants were enabled to draw moisture from below. Where subsoiling is done the same season of planting it is important that it be done early so that capillarity may be restored before the advent of the usual summer drought.

Test of varieties.—Several varieties of beet seed were sent here from various sources with the request that we make a test. This test was made on Plats 41 and 42 of the permanent series of plats. The soil is quite uniform in these plats and all conditions as to preparation, planting, tillage, etc., were alike. The result of the variety test is shown by the following table:

VARIETY TEST.

Plat No.	Date planted.	Variety.	No. of cultures.	Date harvested.	Yield per acre. Tons.	Per cent of solids in juice.	Per cent of sugar in juice.	Per cent Purity.	Per cent of sugar in beet.
41 1st Division.	May 11	Vilmorin Improved, Schlitte & Co.	6	Oct. 28	18	17.1	14.25	83.3	13.54
41 2d Division.	May 11	Zeringen.	6	Oct. 28	19.6	18.	15.55	86.4	14.77
41 3d Division.	May 11	Kleinwanzlebener.	6	Oct. 28	22	17.9	14.90	83.2	14.16
41 4th Division.	May 11	Zeringen.	6	Oct. 28	19.2	19.5	16.40	84.1	15.58
41 5th Division.	May 11	Vilmorin's White Improved.	6	Oct. 28	16.8	16.5	13.00	78.8	12.35
42 1st Division.	May 19	C. Baumier's Kleinwanzlebener.	6	Oct. 28	18	17.8	15.6	87.6	14.82
42 2d Division.	May 19	Pitzschkes Elite.	6	Oct. 28	18	18.6	16.55	89.0	15.72
42 3d Division.	May 19	Kleinwanzlebener from Vilmorin Andrieux & Co.	6	Oct. 28	17.4	17.5	14.05	80.3	13.35
42 4th Division.	May 19	French, very rich, from Vilmorin, Andreux & Co.	6	Oct. 28	21	17.5	14.95	85.4	14.20

The average of results from the 24 plats of various varieties and with various methods of culture was as follows:

AVERAGE OF 24 PLATS.

Yield per acre Tons.	Average wt. of beets analyzed Pounds.	Per cent of solids in juice.	Per cent of sugar in juice.	Purity.	Per cent of sugar in beet.
20.3	1.29	18.7	16.06	85.6	15.13

The above record of results shows a high average for the entire area. No fertilizer of any kind has been used on the land since winter of '93–4 when about 10 loads of strawy barn manure were applied per acre. The land has been heavily cropped every year, and while especially subject to effects of droughts, by proper tillage moisture has been conserved and satisfactory crops harvested. The lesson which should be drawn from the experiments is not so much in the variation between the various plats compared as in the unformly high of all plats. It simply enforces that by thorough preparation of the land and by thorough tillage better results than the average can be obtained.

Experiments with fertilizers for sugar beets.—Experiments with fertilizers on sugar beets were conducted in 1898 upon the "Brick yard" plats. The construction of these plats was described in Bulletin 143 but it is thought well to repeat the description. "In experiments with fertilizers a frequent source of error lies in the fact that the soils of the different plats lacks uniformity and hence the fertilizers appplied do not each have equal opportunity to exercise its full effect. To obviate this difficulty the plats upon which the beets were grown were prepared in the following manner. The soil selected was a gravelly loam and had been cropped heavily for three years without the application of any fertilizer or manure. In the spring of 1897 a space was measured off for fourteen plats each 4 x 5 ft. in size. The soil of this whole area was then removed to a depth of 24 inches, each layer of eight inches being thrown out upon boards by itself. A solid brick cement wall was constructed around each plat and to a depth of two feet below the surface of the ground. This wall was constructed so that there would be no possible chance for the beets in one plat to receive the benefit of the fertilizer applied to any other plat. After the construction of the wall the soil which had been removed was replaced in the inverse order of its removal, the eight inches removed last was returned first so that it would occupy its original place at the bottom. Before being returned each eight inches of soil was thoroughly mixed and then an equal number of pounds was put into each plat and packed. In this way all the plats were filled, each layer of soil after having been thoroughly mixed was returned to its original position."

Fertilizer experiments were continued upon these same plats in 1898, each fertilizer being applied to the plat which received similar fertilizer in 1897.

The table on page 449 gives the record of the plats and the results for 1898.

The plats upon which these experiments were conducted were so limited in area that no estimate is given of the yield per acre. The object of the experiment was to determine what effect if any, the various fertilizers would have upon the quality of the beets grown. The most noticable effect is seen on Plat No. 6, where nitrate of soda was applied. The per cent of sugar and the per cent of purity falling considerably below that of the other plats.

Where more than one chemical were used they were combined in equal proportions and all fertilizers were thoroughly incorporated with the soil before the seed was planted. The results would seem to indicate that the use of nitrate of soda is conducive to the growth of large beets of poor quality. When used it should be in combination with other chemicals unless the soil is markedly deficient in nitrogen.

BRICK YARD PLATS, FERTILIZER EXPERIMENTS, 1898.

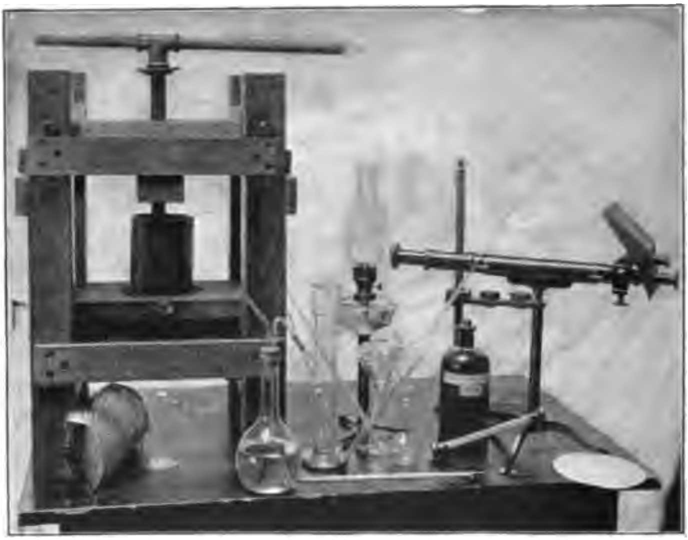
	Date planted.	Variety.	Fertilizer used.	Rate per acre.	Date analyzed.	Av. wt. of beets analyzed.	Per cent of solids in juice.	Per cent of sugar in juice.	Per cent Purity.	Per cent of sugar in beet.
Plat 3	June 10	Kleinwanzlebener	Sulphate of potash	1089 lbs.	Nov. 19	.92	20.6	17.65	85.7	16.77
Plat 4	June 10	Kleinwanzlebener	Superphosphate	1089 lbs.	Nov. 19	.65	20.1	17.25	85.8	16.39
Plat 5	June 10	Kleinwanzlebener	Sulphate of potash Nitrate of soda	1089 lbs. 1089 lbs.	Nov. 19	.91	20.4	17.60	86.3	16.72
Plat 6	June 10	Kleinwanzlebener	Nitrate of soda	1089 lbs.	Nov. 19	1.11	18.4	14.50	78.3	13.78
Plat 7	June 10	Kleinwanzlebener	No fertilizer	1089 lbs.	Nov. 19	.89	20.5	17.	82.9	16.15
Plat 8	June 10	Kleinwanzlebener	No fertilizer	1089 lbs.	Nov. 19	.70	20.4	17.95	88.0	17.05
Plat 9	June 10	Kleinwanzlebener	Sulphate of potash Superphosphate	1089 lbs. 1089 lbs.	Nov. 19	.60	21.6	18.90	87.5	17.96
Plat 10	June 10	Kleinwanzlebener	Nitrate of soda Superphosphate	1089 lbs. 1089 lbs.	Nov. 19	.84	21.1	18.45	87.4	17.53
Plat 11	June 10	Kleinwanzlebener	Sulphate potash Nitrate of soda Superphosphate	1089 lbs. 1089 lbs. 1089 lbs.	Nov. 19	.73	20.3	17.35	85.4	16.48
Plat 12	June 10	Kleinwanzlebener	Muriate of potash	1089 lbs.	Nov. 19	.56	21.2	18.40	86.8	17.48
Plat 13	June 10	Kleinwanzlebener	Lime	1089 lbs.	Nov. 19	.65	20.1	17.60	87.5	16.72
Plat 14	June 10	Kleinwanzlebener	Ground phos. rock	1089 lbs.	Nov. 19	.65	19.5	16.85	86.4	16.01

PART III.

THE WORK OF THE CHEMICAL DIVISION.

BY A. L. KNISELY AND G. W. CAVANAUGH UNDER THE DIRECTION OF G. C. CALDWELL, CHEMIST.

The work of the Chemical Division has been carried along lines very similar to those of a year ago. Samples of beets have been received from several hundred farmers. In most cases the samples were accompanied by reports of the experimental plats.



75. *Apparatus used in the analysis of Sugar Beets.*

The first step in the analysis of sugar beets is to obtain a sample of juice. This process is similar to cider-making. The beets are grated on an ordinary grater, lying under the press. The pulp obtained, about one pint, is put in the cylinder of the press and the juice pressed out flows into the glass cup or beaker under the spout. The juice is then poured into the tall glass cylinder at the left of the lamp. The temperature of the juice must be found with the thermometer, which lies on the table in front of the cylinder. The density or solid matter of the juice is next found by means of the hydrometer, or Brix spindle; this spindle lies against the press with its base at the bottom of the glass cylinder.

The next step is to put a definite amount of the beet juice into the 100 cubic centimeter flask. This flask with a long slender neck and wide mouth is just at the left of the bottle marked "poison." This definite amount of juice is measured out by the large pipette which is just at the left of the bottle and leans against the polariscope. The juice is very dark colored and the coloring matter must be removed. A little of the sub-acetate of lead in the bottle,added to the measured juice in the flask will cause the coloring matter and impurities to coagulate and settle. In front of the lamp is a funnel holding a folded filter paper. The juice is poured into this filter and the clear filtrate is caught in the flask which supports the funnel, whilst the impurities and coloring matter are held back on the filter paper. The juice which runs through the filter paper is just as clear as water and is now ready for analysis (polarization).

In front of the sub-acetate bottle is a glass tube about eight inches long with glass caps on either end that can be screwed on. One of the glass caps is removed, the tube is filled with the clear juice and the cap is replaced so that one can look through the tube endwise. At the extreme right is the saccharimeter, a very costly piece of apparatus. The tube full of juice is put into this saccharimeter in a dark room and the lamp is lighted and placed just in front of the instrument. On looking through the telescope one can see the light of the lamp; the line of vision passes endwise through the tube full of the clear beet juice. By carefully noting how any particular beet juice in the tube affects the rays of light passing through it, we can tell immediately what per cent of sugar there is in that particular juice.

In front of the press is a flask called a wash bottle, containing pure water. Such a bottle is needed always in chemical work.

At the extreme right of the cut is a pile of white filter papers used in filtering juices.

The samples of beets were analyzed as soon as received, or as soon after as possible and in each case a *franked report blank*[*] was filled out giving the analysis of the sample. This report was sent back to the farmer who had sent in the sample for analysis. In this way each experimenter quickly learned the quality of his beets.

The results of the season's work have been carefully tabulated, but it has been thought best not to publish again this year a series of exhaustive tables, but rather to state in a concise form some of the final results of the season's work.

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[*] These report blanks are the size and shape of ordinary postal cards. On the face they have the mark of the U. S. Government which exempts them from postage; on the opposite side is the blank form ready to be filled in with the results of the analysis. These blanks were kindly supplied to the Station by Dr. H. W. Wiley, Chemist of the U. S. Dept. of Agriculture.

In summarizing the work it is necessary to use the terms "total solids," "sugar in juice," "sugar in beet," and "purity;" therefore for the benefit of readers in general these terms are here defined.

1. *Per cent total solids in the juice, or degrees Brix.*—Beet juice consists of water, and of solid matter containing sugar, mineral salts, coloring matter, nitrogenous compounds, etc. A beet juice is said to have 19.9 per cent total solids. This means that 19.9 per cent of that juice is solid matter and the remaining 80.1 per cent is water; or, in other words, in each 100 pounds of such a juice there are 19.9 pounds of solid matter and 80.1 pounds of water.

2. *The per cent of sugar in the juice.*—This per cent is determined by the polariscope. A beet juice is said to analyze 17 per cent sugar. This means that in each 100 pounds of such a juice there are 17 pounds of pure sugar.

3. *The per cent of sugar in the beet.*—The per cent of sugar in the beet is obtained by multiplying the per cent of sugar in the juice by $\frac{95}{100}$. Thus 17 per cent sugar in juice $\times \frac{95}{100} = 16.15$ per cent sugar in the beet. This means that in each 100 pounds of such beets without crowns there are 16.15 pounds of pure sugar.

4. *Per cent of purity of a juice.*—This term is often called the coefficient of purity, or better still the quotient of purity. It expresses the ratio between the *per cent of total solids in the juice* and the *per cent of sugar in that same juice.* That is, in any particular juice, the *purity* expresses what proportion of the total solids is sugar. Thus in a juice analyzed, there is found a *purity of 86.6 per cent.* This means that if such a juice were evaporated to dryness and the total solid matter obtained, then of this solid matter 86.6 per cent would be sugar and the remaining 13.4 per cent would be impurities not sugar; or stated in another way, in every 100 lbs. of the solid matter obtained by evaporating the juice, 86.6 lbs. would be sugar and the remaining 13.4 lbs. would be impurities and not sugar.

In any given case the *purity* is obtained by dividing the *per* *cent of sugar* in the juice by the *per cent of total solids* and multiplying by 100. The term *purity* is not an indication of the quality of a *juice*, but of the quality of the *total solids* in the juice; that is, it tells *how many parts are sugar in every 100 parts of the total solids.*

We shall now take up, first, the general summary of the season's work and then the condensed reports from each county and lastly the meteorological data for 1897 and 1898.

Four hundred and ninety-six samples have been received and analyzed consisting of the following varieties:

Number of analyses.	Variety.
260	Kleinwanzlebener.
81	Vilmorin.
22	Schreiber's German.
12	Zeringen.
7	Very Rich French.
114	Scattering and unnamed.
496	Total.

Giving our attention to the three leading varieties; the Kleinwanzlebener, Vilmorin and Schreiber's German we find that they ranged in quality as follows:

	Kleinwanzlebener.	Vilmorin.	Schreiber's German.
	Samples.	*Samples.*	*Samples.*
Below 12 per cent sugar in beets.......	15	12	0
Between 12–13 per cent sugar in beets..	32	8	0
Between 13–14 per cent sugar in beets..	44	13	2
Between 14–15 per cent sugar in beets..	48	15	4
Between 15–17 per cent sugar in beets..	99	25	9
Above 17..............................	22	8	7
Total............................	260	81	22

The averages of all the analyses made during 1898 of each of these three leading varieties are as follows :

	Kleinwanzlebener average of 260 samples.	Vilmorin average of 81 samples.	Schreiber's German average of 22 samples.
Per cent solids in juice..	18.40	18.30	19.60
Per cent sugar in juice..	15.43	15.07	16.96
Per cent sugar in beets..	14.66	14.32	16.11
Per cent purity.........	83.90	82.30	86.50

This table shows that the Kleinwanzlebener is a little better than the Vilmorin in quality. The Schreiber's German has been tried this year for the first time and it seems to be a very promising variety for New York State. The 22 samples analyzed ranged much better than either Kleinwanzlebener or Vilmorin.

Comparing the results of 1898 with those of the season of 1897, when 495 samples were analyzed, we have the following figures. The averages of the two seasons 1897 and 1898, are given side by side so as to be easily compared.

Season 1897. Average of 495 Samples.		Season 1898. Average of 496 Samples.	
Per cent solids in juice	20.25	Per cent solids in juice	18.30
Per cent sugar in juice	16.91	Per cent sugar in juice	15.29
Per cent sugar in beet	16.06	Per cent sugar in beet	14.53
Per cent purity	83.50	Per cent purity	83.60

A comparison of these two seasons suggests the query, why so much difference in the two cases? Why are the beets so much richer in sugar one year than they are another year? Several causes suggest themselves for this. There is a possibility that the quality of the seed this year was not quite so good as that of a year ago. This season a few new varieties were tried and some of them were of a poor quality and hence tended to lower the general averages of the season's work. The temperature of the two seasons varied somewhat and this probably has been an important factor influencing the amount of sugar produced in the beets.

It is thought that the one condition that had most to do with the decrease of sugar in 1898, was the difference in the amount of moisture.

In 1897 the weather was very favorable for the development of the sugar, especially during September and October; the later month being exceptionally dry and just right for the formation of sugar.

In 1898 the later months of the growing season, especially August, September and October, were very wet as compared with the corresponding months of 1897, so that the beets continued to grow more and mature less than in 1897.

In 1897 the temperature for August and September was below the normal, whilst for the corresponding months of 1898 the temperature was considerably above the normal. This excessive warmth together with the over abundant rainfall, would stimulate plant growth and retard the formation of sugar and also prevent the early maturing or ripening of the beets. (For the weather conditions of the state for 1897 and 1898, see pages 466–7.)

In 1897 beets grown on freshly plowed clover sod, were of poorer quality than those grown on land that had been well tilled the preceding year.

An experiment carried on in 1898 by Mr. C. D. Jackson, of Peruville, supports the conclusion drawn in 1897.

Mr. Jackson grew Kleinwanzlebener sugar beets on corn stubble and also on clover sod, both with and without fertilizer, with the following results:

Kind of soil and how treated.	Per cent solids in juice.	Per cent sugar in juice.	Per cent sugar in beet.	Per cent Purity.
Clover sod with fertilizer............	18.0	13.90	13.21	77.2
Clover sod without fertilizer.........	18.5	14.50	13.78	78.4
Corn stubble with fertilizer..........	18.6	16.50	15.68	88.8
Corn stubble without fertilizer.......	19.0	15.30	14.54	80.5

These results are decidedly in favor of planting upon recently plowed corn stubble.

Mr. C. M. Lusk, of Centre Lisle, also experimented along the same line and tested the relative merits of corn stubble and clover sod for producing high quality beets. He experimented with three varieties of beets and got no great difference in quality and the results were somewhat contradictory. They are as follows:

Soil.	Variety of Beet.	Per cent solids in juice.	Per cent sugar in juice.	Per cent sugar in beet.	Per cent Purity.
Clover sod.	Kleinwanzlebener.	19.6	16.90	16.06	86.2
Corn stubble.		18.6	16.45	15.63	88.4
Clover sod.	Vilmorin.	18.6	15.60	14.82	83.8
Corn stubble.		18.5	15.90	15.11	85.9
Clover sod.	Schreiber's German.	19.8	17.50	16.63	88.4
Corn stubble.		19.9	17.20	16.34	86.4

Comparison of sandy and clay loams, eighty-four samples were grown on sandy loam, and 48 samples on clay loam. The averages of the results from these two types of soil are as follows:

	Sandy loam. Average of 84 samples.	Clay loam. Average of 48 samples.
Per cent solid in juice....	18.20	18.60
Per cent sugar in juice...	15.24	15.44
Per cent sugar in beet....	14.48	14.67
Per cent purity...........	84.30	84.10

These results would seem to indicate that there is little or no difference between *clay loam* and *sandy loam* for producing beets of high quality. The sugar content of the juice is 0.2 per cent higher on clay loam, whilst the purity is 0.2 per cent higher on sandy loam.

On the following pages are given the results of the season's (1898) work by counties. The work has been greatly condensed and a few of the general averages only are presented.

In cases where but few experiments are recorded, one must guard against drawing too sweeping conclusions. They may often be misleading.

Allegany—Twelve samples were analyzed of which 7 were Kleinwanzlebener and the remainder miscellaneous samples.

The Kleinwanzlebener ranged in quality as as follows:

From 12–13 per cent sugar in beet, 1 sample; 13–14 per cent no sample; 14–15 per cent, 2 samples; 15–17 per cent, 2 samples, above 17 per cent, 2 samples.

These beets were grown mostly on sandy and gravelly loam. The average of the analyses of the 7 samples is as follows:

Per cent solids in juice....................	20.00
Per cent sugar in juice....................	16.71
Per cent sugar in beet....................	15.87
Per cent purity..........................	83.60

The richest beet of the season came from this county and was a Kleinwanzlebener grown on stiff clay with a hard-pan subsoil. It analyzed as follows :

Per cent solids in juice	23.80
Per cent sugar in juice	21.00
Per cent sugar in beet	19.95
Per cent purity	88.20

Broome.—Fourteen samples were analyzed including 5 Kleinwanzlebener and 4 Vilmorin. The remaining samples were miscellaneous. The quality of these two varieties was as follows :

Between 14–15 per cent sugar in beet 1, Kleinwanzlebener, 2 Vilmorin ; 15–17 per cent, 3 Kleinwanzlebener, 2 Vilmorin ; above 17 per cent 1 Kleinwanzlebener.

The averages of the analyses of these two varieties are given below :

	Kleinwanzlebener. Average of 5 samples.	Vilmorin. Average of 4 samples.
Per cent solids in juice	19.50	18.50
Per cent sugar in juice	17.11	15.70
Per cent sugar in beet	16.25	14.92
Per cent purity	87.70	84.90

Samples were grown mostly on sandy loam.

Cattaraugus. — Twenty-three samples were received consisting of 11 Kleinwanzlebener, 7 Vilmorin and the remainder miscellaneous samples.

The Kleinwanzlebener and Vilmorin varieties ranged in quality as follows :

Below 12 per cent sugar in beet, 1 Kleinwanzlebener, 2 Vilmorin ; from 12–13 per cent, 1 Kleinwanzlebener, 1 Vilmorin ; from 13–14 per cent, 2 Kleinwanzlebener ; from 14–15 per cent, 1 Kleinwanzlebener ; from 15–17 per cent, 4 Kleinwanzlebener, 3 Vilmorin ; above 17 per cent, 2 Kleinwanzlebener, 1 Vilmorin.

Below are given the averages of the analyses of these two varieties :

	Kleinwanzlebener. Average of 11 samples.	Vilmorin. Average of 7 samples.
Per cent solids in juice	17.80	17.80
Per cent sugar in juice	14.93	14.34
Per cent sugar in beet	14.18	13.62
Per cent purity	83.90	80.60

These varieties were grown chiefly on gravelly and clay loam.

Chautauqua—One hundred and thirty-seven samples were received, consisting of 86 Kleinwanzlebener, 27 Vilmorin and the remainder miscellaneous varieties. Beets ranged in quality as follows: Below 12 per cent sugar in beet, 5 Kleinwanzlebener, 6 Vilmorin; from 12–13 per cent, 19 Kleinwanzlebener, 3 Vilmorin; from 13–14 per cent, 18 Kleinwanzlebener, 4 Vilmorin; from 14–15 per cent, 15 Kleinwanzlebener, 3 Vilmorin; from 15–17 per cent, 24 Kleinwanzlebener, 7 Vilmorin; above 17 per cent, 5 Kleinwanzlebener, 4 Vilmorin.

The averages of the analyses of these two varieties are given below.

	Kleinwanzlebener. Average of 86 samples.	Vilmorin. Average of 27 samples.
Per cent solids in juice	18.00	18.20
Per cent sugar in juice	14.86	14.98
Per cent sugar in beet	14.12	14.23
Per cent purity	82.60	82.30

Of the 86 samples of Kleinwanzlebener, 17 were grown on clay loam, 23 on gravelly to gravelly loam and 10 on sandy to sandy loam. Their quality was as follows :

	Clay loam. Average of 17 samples.	Gravelly loam. Average of 23 samples.	Sandy loam. Average of 10 samples.
Per cent solids in juice..	18.50	18.40	18.10
Per cent sugar n juice..	15.65	15.31	15.19
Per cent sugar in beet...	14.87	14.54	14.43
Per cent purity.........	84.60	83.20	83.90

Giving our attention to the Vilmorin variety; of the total number received from Chautauqua County, 3 were grown on clay loam, 7 on gravelly loam and 4 on sandy loam. Their quality ranged as follows:

	Clay loam. Average of 3 samples.	Gravelly loam. Average of 7 samples.	Sandy loam. Average of 4 samples.
Per cent solids in juice.	18.50	19.10	19.20
Per cent sugar in juice..	15.23	15.86	16.31
Per cent sugar in beet...	14.47	15.07	15.50
Per cent purity.........	82.30	83.00	84.90

Chemung—Sixteen samples were received of which 6 were Kleinwanzlebener, 4 Zeringen, 3 Vilmorin, and 3 Schreiber's German. With two exceptions these samples were all grown on sandy loam. The averages of the analyses of these several varieties are as follows:

	Kleinwanzlebener. Average of 6 samples.	Vilmorin. Average of 3 samples.	Zeringen. Average of 4 samples.	Schreiber's German. Average of 3 samples.
Per cent solids in juice......	18.20	18.10	17.70	18.20
Per cent sugar in juice......	15.39	15.25	14.75	15.67
Per cent sugar in beet.......	14.62	14.49	14.01	14.89
Per cent purity..............	84.60	84.30	83.30	86.10

Erie — Twenty-five samples were analyzed consisting of 11 Kleinwanzlebener, 8 Vilmorin and the remainder miscellaneous. Giving our attention to the Kleinwanzlebener and Vilmorin varieties we find that they ranged in quality as follows:

Below 12 per cent sugar in beet, 3 Kleinwanzlebener, 2 Vilmorin; from 12–13 per cent, 1 Vilmorin; from 13–14 per cent, 3 Kleinwanzlebener, 1 Vilmorin; from 14–15 per cent, 3 Kleinwanzlebener, 3 Vilmorin; from 15–17 per cent, 2 Kleinwanzlebener, 1 Vilmorin.

The averages of the analyses of these two varieties are given below:

	Kleinwanzlebener. Average of 11 samples.	Vilmorin. Average of 8 samples.
Per cent solids in juice	17.40	17.60
Per cent sugar in juice	14.37	14.29
Per cent sugar in beet	13.65	13.57
Per cent purity	82.60	81.20

Samples grown on *light clay* and *sandy loam* were of better quality than those grown on *heavy clays*.

Genesee—Fifty-five samples were received and analyzed consisting of 29 Kleinwanzlebener, 12 Vilmorin, 6 Schreiber's German and the remainder miscellaneous.

The beets ranged in quality as follows:

Between 12–13 per cent sugar in beet, 1 Kleinwanzlebener, 2 Vilmorin; from 13–14 per cent, 4 Kleinwanzlebener, 2 Vilmorin; from 14–15 per cent, 9 Kleinwanzlebener, 1 Vilmorin, 1 Schreiber's German; from 15–17 per cent, 13 Kleinwanzlebener, 4 Vilmorin, 2 Schreiber's German; above 17 per cent, 2 Kleinwanzlebener, 3 Vilmorin and 3 Schreiber's German.

The averages of the analyses of the three varieties are given below :

	Kleinwanzlebener. Average of 29 samples.	Vilmorin. Average of 12 samples.	Schreiber's German Average of 6 samples.
Per cent solids in juice..	18.80	19.00	20.20
Per cent sugar in juice..	15.87	15.94	17.66
Per cent sugar in beet...	15.05	15.14	16.78
Per cent purity..........	84.40	83.90	87.40

The predominating soils in Genesee County are not heavy, being light clay, sandy and gravelly loams.

Livingston — Ten samples were received consisting of 5 Kleinwanzlebener and the remaining varieties scattering.

Considering the Kleinwanzlebener we have :

One sample below 12 per cent sugar in beet, 3 ranging from 12–13 per cent and 1 sample above 17 per cent sugar.

The average of the analyses is given below :

	Kleinwanzlebener. Average of 5 samples.
Per cent solids in juice.	17.00
Per cent sugar in juice.	13.58
Per cent sugar in beet..	12.90
Per cent purity........	79.90

The soil upon which these samples were grown was chiefly sandy loams.

Monroe—Eight samples were received consisting of 2 Kleinwanzlebener, 3 Vilmorin ; 1 Zeringen, 1 Schreiber's German and 1 unnamed sample.

The averages of the analyses are as follows :

	Kleinwanzlebener. Average of 2 samples.	Vilmorin. Average of 3 samples.	Zeringen 1 sample.	Schreiber's German. 1 sample.
Per cent solids in juice......	19.80	20.00	18.00	20.60
Per cent sugar in juice......	16.15	16.83	14.35	17.25
Per cent sugar in beet.......	15.34	15.99	13.63	16.39
Per cent purity.............	81.60	84.50	79.70	83.70

Niagara — Nine samples were received, of which 6 were Kleinwanzlebner, 2 Vilmorin and 1 unnamed.

The Kleinwanzlebener ranged in quality as follows:

One sample between 13–14 per cent sugar in beet, 3 ranging from 14–15 per cent and 2 from 15–17 per cent.

The average of the analyses of the Kleinwanzlebener is given below.

	Kleinwanzlebener. Average of 6 samples.
Per cent solids in juice.	18.30
Per cent sugar in juice.	15.49
Per cent sugar in beet..	14.72
Per cent purity........	84.60

Orleans — Seventeen samples were received, consisting of 13 Kleinwanzlebener and 4 scattering varieties.

The quality of the Kleinwanzlebener ranged as follows:

One sample below 12 per cent sugar in beet, 1 between 13–14 per cent, 2 between 14–15 per cent, 7 ranging from 15 to 17 per cent and 2 above 17 per cent sugar.

These Kleinwanzlebener gave an average analysis as follows:

	Kleinwanzlebener. Average of 13 samples.
Per cent solids in juice.	19.20
Per cent sugar in juice.	16.48
Per cent sugar in beet..	15.66
Per cent purity........	85.80

These samples were all grown upon light soils, chiefly sandy loams.

Steuben—Nine samples were received consisting of 8 Kleinwanzlebener and 1 Vilmorin.

Of the Kleinwanzlebener, 1 sample ranged between 13–14 per cent sugar in beet, 1 from 14–15 per cent, 5 from 15–17 per cent and 1 sample above 17 per cent sugar.

The averages of the analyses of the two varieties from Steuben county are given below:

	Kleinwanzlebener. Average of 8 samples.	Vilmorin. 1 sample.
Per cent solids in juice...	18.90	18.80
Per cent sugar in juice...	16.20	15.90
Per cent sugar in beet ...	15.39	15.11
Per cent purity..........	85.70	84.50

These samples were all grown upon light sandy and gravelly loams.

Tompkins—Eighty-three samples were received at the laboratory of which 61 samples came from the Cornell University Experiment Station plats.

Of the two leading varieties the following samples were received; 67 Kleinwanzlebener and 6 Vilmorin, 10 samples consisted of miscellaneous varieties.

The Kleinwanzlebener and Vilmorin ranged in quality as follows:

Below 12 per cent sugar in beet, 2 Kleinwanzlebener; from

12–13 per cent, 5 Kleinwanzlebener, 1 Vilmorin; from 13–14 per cent, 13 Kleinwanzlebener, 2 Vilmorin; from 14–15 per cent, 9 Kleinwanzlebener, 2 Vilmorin; from 15–17 per cent, 33 Kleinwanzlebener, 1 Vilmorin; above 17 per cent, 5 Kleinwanzlebener. The averages of the analyses of these two varieties are as follows:

	Kleinwanzlebener. Average of 67 samples.	Vilmorin. Average of 6 samples.
Per cent solids in juice...	18.70	18.10
Per cent sugar in juice...	15.79	15.01
Per cent sugar in beet....	15.00	14.26
Per cent purity..........	84.40	82.90

Samples in Tompkins county were grown mostly on clay loam.

Tioga—Twelve samples were received consisting of 3 named and one unnamed varieties. The averages of the analyses are here given.

	Kleinwanzlebener. Average of 4 samples.	Vilmorin. Average of 3 samples.	Schreiber's German. Average of 2 samples.	Unnamed. 1 sample.
Per cent solids in juice	15.80	17.50	17.70	18.90
Per cent sugar in juice.	12.74	14.33	14.95	15.67
Per cent sugar in beet..	12.10	13.61	14.20	14.89
Per cent purity........	80.60	81.90	84.40	82.90

Wyoming—Five samples were received consisting of 1 Kleinwanzlebener and 4 Vilmorin.

The averages of the analyses of the two varieties are as follows:

	Kleinwanzlebener. 1 sample.	Vilmorin. Average of 4 samples.
Per cent solids in juice...	19.90	17.90
Per cent sugar in juice...	17.15	14.69
Per cent sugar in beet....	16.19	13.96
Per cent purity	86.20	82.10

*New York State Weather Conditions,*from April 1st to October 31st, 1897, compared with those of the corresponding months for 1898.*

APRIL, '97—There was a slight increase over the normal rainfall for most of the state. Temperature 1.3 degrees above the normal.

APRIL, '98—The average rainfall for the state was 0.25 inches above the normal amount. Temperature 1.0 degrees below the normal.

MAY, '97—Decidedly more than the normal rainfall. Temperature averaged 0.8 degrees below the normal.

MAY, '98—The average rainfall for the state was 0.86 inches above the normal. Temperature very nearly normal.

JUNE, '97—Very nearly normal rainfall. Temperature 4.1 degrees below the normal.

JUNE, '98—The average rainfall for the state was 0.72 inches below the normal. Temperature 1.0 degrees above normal.

JULY, '97—Extremely wet, having 3.26 inches more than normal rainfall. Temperature 2.4 degrees above the normal.

JULY, '98—Rather dry, having 1.03 inches below the normal rainfall. Temperature 2.4 degrees above the normal.

AUGUST, '97—Slightly below the normal rainfall. Temperature averaged 1.7 degrees below normal.

AUGUST, '98—Extremely wet, having 2.34 inches more than normal rainfall. Temperature 2.5 degrees above the normal.

SEPTEMBER, '97—Dry, 1.37 inches below the normal rainfall. Temperature 0.1 degree below normal.

SEPTEMBER, '98—The average rainfall for the state was 0.41 inches below the normal. Temperature 3.2 degrees above normal.

OCTOBER, '97—Exceedingly dry, 2.45 inches below the normal rainfall. Temperature 2.8 degrees above the normal.

OCTOBER, '98—Very wet, the rainfall being 1.50 inches above the normal. Temperature 2.8 degrees above the normal.

The following table gives the rainfall for each month, April to October inclusive, in those counties that have grown sugar beets and have had analyses made at the Cornell Experiment Station in 1897. In 1898 fifteen of these counties again grew beets for the Station. If there are two or more *Signal Stations* in a county reporting rainfall, then the average rainfall of the several stations is given.

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*Condensed from the New York State Weather Bureau Report, Central Office at Cornell University. Professor E. A. Fuertes, Director, Ithaca, N. Y.

PRECIPITATION IN INCHES, 1897 AND 1898 COMPARED BY MONTHS.

	COUNTY.	April, 1897.	April, 1898.	May, 1897.	May, 1898.	June, 1897.	June, 1898.	July, 1897.	July, 1898.	Aug., 1897.	Aug., 1898.	Sept., 1897.	Sept., 1898.	Oct., 1897.	Oct., 1898.
1	Albany........	3.12	2.63	4.69	4.07	4.45	5.58	6.67	1.07	**4.43**	**6.67**	**1.87**	**1.61**	**1.01**	**4.29**
2	Broome.......	2.16	3.20	4.45	3.79	3.35	2.46	2.42	2.12	**1.61**	**7.42**	**3.30**	**2.55**	**0.74**	**5.39**
3	Cattaraugus...	2.08	3.00	3.62	4.09	2.71	5.89	6.83	3.63	**2.63**	**8.06**	**1.25**	**2.87**	**0.56**	**5.75**
4	Cayuga........	2.34	2.60	2.92	3.86	3.93	3.30	4.11	1.93	**2.26**	**5.65**	**3.27**	**4.12**	**1.31**	**4.91**
5	Chautauqua ...	3.29	3.08	3.65	4.61	2.32	5.56	6.79	2.57	**3.55**	**4.71**	**0.81**	**2.26**	**1.56**	**5.14**
6	Erie..........	2.18	1.73	2.72	2.19	1.87	2.24	6.16	1.72	**1.93**	**2.77**	**0.47**	**3.39**	**1.07**	**3.98**
7	Genesee*......	1.87	1.62	2.45	2.23	1.85	3.00	4.54	2.20	**1.49**	**4.88**	**0.84**	**3.48**	**1.04**	**3.99**
8	Herkimer......	3.99	3.77	4.73	4.40	5.47	4.40	5.00	2.72	**2.98**	**9.51**	**1.88**	**3.73**	**1.38**	**4.03**
9	Jefferson	2.16	1.75	3.74	2.98	2.05	2.58	8.22	1.37	**3.54**	**4.35**	**0.78**	**3.65**	**0.42**	**3.80**
10	Livingston	1.66	2.37	2.15	3.45	2.03	4.11	3.14	2.18	**0.55**	**5.57**	**1.21**	**2.29**	**0.66**	**3.83**
11	Monroe........	2.10	1.80	1.94	3.20	2.65	0.98	6.10	1.54	**1.46**	**4.61**	**0.77**	**3.68**	**0.92**	**3.69**
12	Montgomery...	1.93	2.45	4.10	3.71	4.91	3.35	5.58	4.26	**3.13**	**6.14**	**1.89**	**2.77**	**0.84**	**5.46**
13	Niagara	2.52	1.58	2.87	2.29	1.79	2.88	5.68	1.49	**1.54**	**3.43**	**0.93**	**4.85**	**1.06**	**4.15**
14	Oneida........	3.36	3.83	4.12	4.35	4.87	4.16	4.92	4.09	**2.71**	**3.15**	**2.30**	**4.65**	**0.38**	**4.79**
15	Onondaga	2.67	2.23	2.77	3.84	3.19	2.14	5.44	1.55	**2.36**	**6.70**	**1.97**	**3.98**	**0.80**	**3.89**
16	Orleans........	2.62	1.49	2.77	2.03	1.77	2.67	5.07	1.35	**2.08**	**3.71**	**0.38**	**3.58**	**1.01**	**3.31**
17	Oswego.	2.19	2.05	2.60	3.88	3.67	1.61	3.98	2.51	**2.42**	**3.82**	**1.09**	**4.18**	**0.57**	**4.84**
18	Saratoga	3.68	3.07	6.35	4.81	6.63	3.16	8.83	2.43	**4.70**	**8.03**	**1.65**	**3.13**	**1.45**	**5.05**
19	Schuyler	2.64	3.28	3.00	3.38	3.00	3.09	3.27	2.65	**2.19**	**4.70**	**2.66**	**1.99**	**0.71**	**6.11**
20	Seneca.......	2.53	3.60	4.80	4.31	2.71	3.42	4.14	2.42	**0.78**	**4.97**	**3.95**	**2.03**	**1.21**	**3.19**
21	Steuben.......	2.55	2.87	3.54	3.56	2.56	3.70	6.30	3.13	**2.49**	**4.49**	**2.51**	**1.83**	**0.96**	**5.41**
22	Tioga	2.95	3.76	3.98	4.56	3.59	3.07	4.32	2.99	**3.19**	**7.05**	**4.05**	**2.26**	**0.56**	**6.06**
23	Tompkins	2.65	3.58	3.90	4.07	3.65	2.76	3.78	4.88	**2.48**	**4.95**	**4.59**	**3.05**	**0.94**	**5.04**
24	Wayne........	2.33	2.16	1.98	3.60	3.85	2.06	4.44	2.51	**1.19**	**5.58**	**1.15**	**3.21**	**0.62**	**4.66**
25	Yates.........	......	2.23	......	2.66	......	3.35	.....	2.08	**1.28**	**4.16**	**1.90**	**1.88**	**0.62**	**5.53**

* No report sent in, so the rainfall given is the average for Signal Stations at Ridgeway, Avon and Akron.

76.—*Factory of the First New York Beet Sugar Co. at Rome.*

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55 Greenhouse Notes, 31 pp.
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69 Hints on the Planting of Orchards, 16 pp.
71 Apricot Growing in Western New York, 26 pp.
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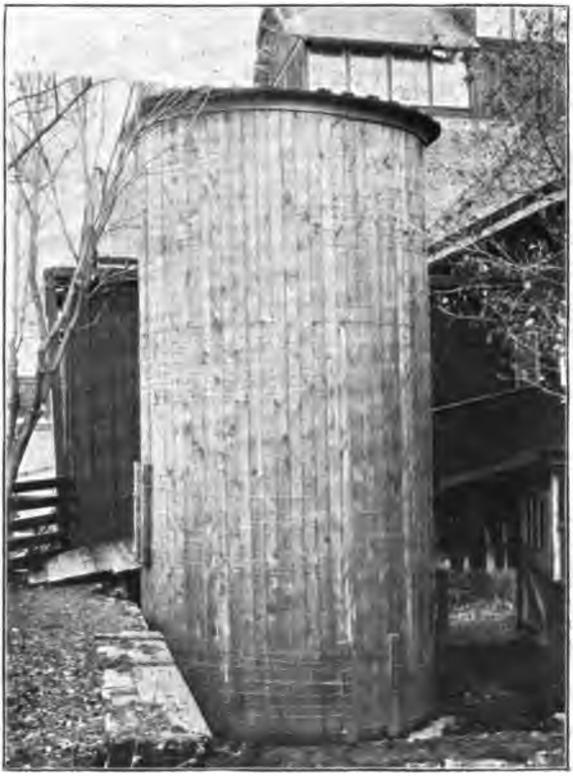
UNIV. OF MICH.
APR 26 1899

Bulletin 167. **March, 1899.**
Cornell University Agricultural Experiment Station,
ITHACA, N. Y.
AGRICULTURAL DIVISION.

The Construction of the Stave Silo.



By L. A. CLINTON.

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ITHACA, N. Y.
1899

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The regular bulletins of the Station are sent free to all who request them.

CORNELL UNIVERSITY, March 21, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY, N. Y.

Sir: As the dairy industry of the state is developed it becomes of more importance each year that the capacity of the farms to sustain stock be not only maintained, but increased. If the capacity is to be increased, there must be provided some means for storing the roughage or fodder produced on the farm. Of the various forms of roughage, there are none which compare in cheapness of production and value of product, with Indian corn or maize. This crop is becoming the mainstay of the dairy farmer. The question which he has been called upon to decide, is, how this product may be most economically stored. Of all the methods which have been suggested, the ensilaging of corn seems to most fully preserve its original feeding value. Hitherto, the draw-back to this method of storage, has been the imperfection of silos. With the old square or rectangular forms of construction the percentage of waste has been so great that many farmers have hesitated to construct silos. For more than three years we have been carefully studying the points of merit of the stave silo, and it seems to overcome almost entirely the objections which have been made against the square and rectangular forms. As the demand for information with reference to the construction of the stave silo has increased each year it has been thought wise to publish in bulletin form, information as to details of construction. This information is, therefore, offered for publication as a bulletin under Chapter 67, Laws of 1898.

I. P. ROBERTS, Director.

THE STAVE SILO.

The value of good silage has become so generally recognized that it is unnecessary to enter into any discussion on that point. Especially to the dairy farmer has the silo become an almost necessary adjunct to the equipment of the farm. Dr. W. H. Jordan, Director of the New York State Experiment Station, Geneva, N. Y., in an address before the N. Y. State Dairymen's Convention in 1897 said, "Silage properly made and properly fed never yet injured a pound of milk."

The trouble with much of the silage fed, is that it fails to comply with one or the other and frequently both of the above conditions. One cause which has contributed more than any other toward poor silage has been faulty construction of the silo. No matter how good the corn when ensilaged nor how carefully and intelligently the silage may be fed, if the silo is so constructed that a moldy, sour product results, satisfactory returns from feeding cannot be secured. Reasons frequently offered as an excuse by farmers for not having a silo are the facts that the percentage of loss is usually considerable and the original cost of the silo is beyond their means. The stave silo more nearly overcomes these objections than any other form of silo which has been proposed. The important features which must be possessed by a silo to adapt it to the needs of the masses are, first, ability to preserve the silage; second, cheapness and simplicity of construction; third, durability.

After making for three years careful study and observation of the stave silo we believe it meets fully the above requirements, and that it is the most practical and successful silo which can be constructed. The round stave silo presents no corners which may pull apart and admit air, and which cause the silage to settle unequally; the original cost is very slight as no expert labor is required, all mason and carpenter work can be done by the usual farm help. The material used in construction is the minimum amount for obtaining the maximum capacity; the durability of the stave silo is as yet only a matter of conjecture for decay has not commenced on any stave silo which we have examined.

A stave silo built at Cornell University in 1898, has a part of the staves of hemlock, a part of Georgia pine, part of white pine and part of cypress. These different materials will be carefully observed in future years to determine their relative value.

As many letters of inquiry have been received during the past year asking for information about silos and details for the construction of the stave silo it has been thought wise to publish a bulletin which should give somewhat fully the information called for.

The location of the silo.—A silo should be located with reference to facility in feeding. This condition is important above all others. If stock are housed in the basement it is well to have the bottom of the silo on a level with the floor of the basement. It is cheaper to elevate the silage at the time of filling the silo when it can be done on a carrier by steam power, than to elevate it in baskets at time of feeding when it must usually be done by man power. The practice of digging pits into which to put the silage is not to be commended as it causes an unnecessary expense at the outset and is afterwards a source of extra labor and annoyance when the silage is fed.

Whether the silo shall be placed on the interior or exterior of the barn must be determined for each individual case. If at the time the barn is planned arrangements are made for the silo it can nearly always be placed on the interior. If, however, it is desired to erect a silo and the barn is already constructed it is usually more convenient to place the silo on the exterior. It is very largely a matter of economizing space and labor. If placed inside the barn no extra expense need be incurred for roofing, the work is concentrated and it will usually be found more convenient than placing the silo on the outside. Some caution must be observed especially if the silo is located near the milking room and the silage should not be thrown down until the milk is removed from the range of its odor. Wherever the silo is located it should be with reference to economizing labor in feeding and it should be placed at the point most convenient regardless of any slight extra expense which may be incurred by so doing.

Size of silo to construct.—In calculating the amount of silage which will likely be needed, it is customary to estimate that a 1000 pound cow will consume about 40 pounds or one cubic foot of silage per day. This gives a basis upon which to calculate the capacity of the silo required to carry a certain amount of stock One cow to be fed a full ration of silage, say from November 1st to May 1st, would require 7,240 pounds which would necessitate a storage capacity in the silo of 181 cubic feet. If, say 20 cows are to be fed during the period above mentioned there would be required 144,800 pounds of silage necessitating a storage capacity in the silo of 3,620 cubic feet. It frequently becomes a question of considerable importance to know how large a silo should be constructed in order to furnish the necessary storage room. The following table showing the approximate capacity, in tons, of silos of various depths and diameters, may be found useful.

Table showing approximate total capacity of cylindrical silos for well matured corn silage, in tons.

Depth. Feet.	Inside Diameter in feet.										
	12	15	16	17	18	19	20	21	22	23	24
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
20	45	70	80	90	101	113	125	138	151	167	180
21	47	74	84	95	106	118	132	145	159	173	190
22	49	77	88	99	111	124	138	152	166	182	198
23	52	81	92	104	117	130	144	159	174	190	207
24	54	84	96	108	122	135	150	166	179	199	216
25	56	88	100	113	127	141	157	173	189	207	225
26	59	92	104	118	132	147	163	180	197	215	235
27	61	95	108	122	137	153	169	187	205	224	244
28	63	98	112	126	142	158	175	193	212	232	252
29	65	101	116	131	147	164	182	200	220	240	262
30	67	105	120	136	152	170	188	207	227	249	271

In making out the above table the mean weight of a cubic foot of well settled silage has been taken as 40 pounds. While this is only an approximation, yet it comes near enough to enable us to estimate the capacity of silos. It is known that in the upper part of a silo 24 feet deep, a cubic foot of silage will not weigh more than 35 to 38 pounds, while in the lower part the weight will run from 40 to 45 pounds. At Cornell University a silo 24 feet deep was filled with well matured corn during the latter part of September 1898. After allowing it to settle for four or five days it was filled again to the top. This was repeated three times, the silo being filled to the top each time after it had been allowed to settle. It was finally covered over with about one foot of freshly cut second growth clover. When the silo was opened in November the silage had settled so that the top of it was five feet below the top of silo. On the 25th day of February 1899 several samples each consisting of one cubic foot of settled silage were weighed. These samples were taken at a depth of 14 feet from the top of the silo and 9 feet below where the top of the settled silage had been. The weight of one cubic foot of silage at the depths above mentioned was found to be 38 pounds.

How to use the above table.—The table given above is to enable one who contemplates constructing a silo to estimate the size of silo which will be needed. From 25 to 30 pounds of silage per cow is regarded as a light daily ration, 35 to 40 pounds as a medium and 40 to 50 as liberal. If it is assumed that 40 pounds of silage or one cubic foot per day, will be about the amount fed per cow, we can then closely estimate the size of silo needed.

The table gives the capacity of silos could they be filled with settled silage. Practically this is never possible. If the silo is filled with well matured corn and then after the silage has settled is filled again and this is repeated two or three times, we can get only about three-fourths the maximum capacity of the silo in settled silage. If the silo is filled but once and is not refilled after the silage has settled, not more than two-thirds the capacity of the silo can be obtained in settled silage. Thus if the silo can be filled in the manner first mentioned one should be constructed which has a maximum capacity one-third greater than for the amount of silage required. If the silo is to be filled rapidly and not refilled after settling, it should have a capacity one-half greater than for the actual amount of silage required.

If, as in the case previously mentioned, 20 cows are to be fed from Nov. 1st to May 1st a period of 181 days there will be consumed 72.4 tons of silage.

If the silo be filled by the first method there will be needed in this case a maximum capacity for 96 tons, which will be nearest met by a silo 24 feet deep and 16 feet in diameter. If the silo is filled according to the second method, there will be needed a maximum capacity for 108 tons, which will be most nearly met by a silo 27 feet deep and 16 feet in diameter. It is always well to construct a silo somewhat larger than the present needs seem to demand. Then as the herd increases or the use of silage increases, extra silo capacity will have been already provided.

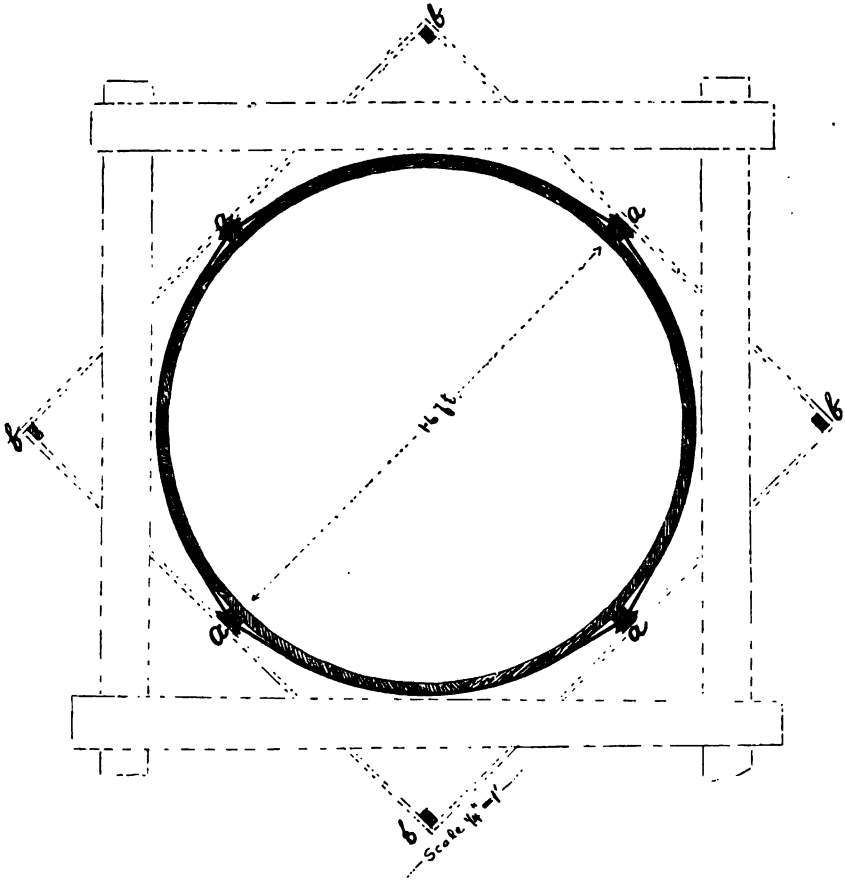
Construction of foundation for stave silo.—Where the silo is to be constructed an excavation should be made to a depth of 3 or 4 inches or to the bottom of the loose surface soil and with a diameter at least two feet greater than the proposed diameter of the silo and drainage should be provided if the conditions seem to warrant. The excavation should be filled with stones, large ones being placed at the bottom and smaller ones being worked in and pounded down toward the top. Gravel if well pounded down may serve as filling between the stones. It is important that the pounding be thoroughly done, otherwise settling will take place later on and the cement finish be made to crack.

The finishing should be done with cement. First a thin mortar made of one part of Portland or Rosendale cement and four parts of good sharp sand should be poured over the entire stone work. This mortar should be made so thin that it will run down into the interstices between the stones. After this first coat has thoroughly set a finishing coat made of one part cement and three parts of sand should be put on and worked down with a trowel. Finish off before thoroughly dry by dusting over the top some clear cement and working it in with a trowel. This will give a hard finish and will secure a foundation that is cheap and efficient. While the cement is still soft it is frequently convenient to strike the circle which will mark the line upon which the staves are to be set. A spike driven in the center will serve as a pivot. Attach to this a bit of string or twine the length of which shall be one-half that of the proposed diameter of the silo and to the free end of the string fasten some pointed instrument with which to mark the circle. Now strike a circle the radius of which shall be equal to the length of the string and there is marked out the circle upon which the staves are to be set.

Material to use for staves.—It is probable that no better material can be obtained for the staves than Southern cypress. This, however, is so expensive in New York State as to preclude its use in most cases. Of the cheaper materials hemlock, white-pine, and yellow-pine are usually the most available. At the present time hemlock is one of the cheapest satisfactory materials which can be purchased and it is probably as good as any of the cheaper materials. It should be sound and free from loose knots.

Preparation of the staves for the silo.—If the silo is to have a diameter of 12 feet or less the staves should be made of either 2 x 4 material unbevelled on the edges and neither tongued nor grooved, or of 2 x 6 material bevelled slightly on the edges to make the staves conform to the circular shape of the silo. If the silo is to have a diameter of more than 12 feet the staves should be of 2 x 6 material and neither bevelled nor tongued and grooved on the edges. If the staves are left perfectly plain, then when they are set in place and drawn together the first point of contact will be the inner edge and the tighter the hoops are drawn the closer will become the contact of the staves at the inner edge. If it is impossible to purchase material for staves the length of which shall be equal to the desired depth of the silo then shorter staves may be used and set up according to the method hereafter described. The staves should be surfaced on the inside so that a smooth face may be presented which will facilitate the settling of the silage. Whether the outside of the staves shall be planed is a matter of taste, but if hemlock is used the handling of the staves will be found much easier if both sides are planed.

Setting up the silo.—There are several methods of procedure which may be followed in setting up the silo. Fig. 77 shows a cross section of one method of construction. The posts (a, a, a, a,) should be of 6 x 6 material and run the entire length of the silo. These should be first set up vertically and stayed securely in place and then they may be used as part of the scaffolding, they will also serve to give rigidity to the staves as the work of setting up progresses, and when the roof is put on, the plates which support the roof may be laid on these posts. The scaffolding may be constructed by setting up 2 x 4 scantling in the positions shown in fig. 77 as *b b b b.* Boards nailed from these 2 x 4 scantling and to the 6 x 6 posts will form a rigid frame work across which the planks for the scaffold platform may be laid. Before the scaffolding is all in place the staves should be stood up within the inclosure, otherwise difficulty will be experienced in getting them into position. Some caution needs to be exercised in working on the scaffolding that the planks do not tip, but with ordinary care there need be no danger. The first stave set up should be made



77.—*Shows cross section of stave silo, the dotted lines are to show how scaffolding may be put up.*

plumb and should be toe-nailed at the top to one of the posts originally set.

If one man works at the top of the staves and one at the bottom with another man to assist in raising them in position they may be set up very rapidly. Immediately a stave is set in place it should be toe-nailed at the top to the preceding stave set. It has been found that the work of setting up and preserving the circular outline may be materially aided by the use of old barrel staves. For a silo 12 feet in diameter the curve in the stave of the sugar barrel is best adapted, for a 16 foot silo the flour barrel stave is best and for a silo 20 feet or more in diameter the stave of the cement barrel is best. Before commencing to set up the silo there should be at hand an abundance of old barrel staves of the kind best adapted to the work as designated above. When a silo stave is set in place nail to it horizontally and on the inside a barrel stave. One barrel stave will reach across several of the silo staves and should be secured by shingle nails to each silo stave. One row of barrel staves should be nailed on or near the top and one near or below the middle. These barrel staves assist in keeping the silo on the proper curve and do away with the necessity of making a mold or form. Fig. 78 shows how the barrel staves are used. If when the silo staves are put in place they are toe-nailed securely to the ones previously set; if they are fastened firmly to the permanent upright posts (a, a, a, a fig. 77); if the barrel staves are used as directed above, the silo will have sufficient rigidity to stand

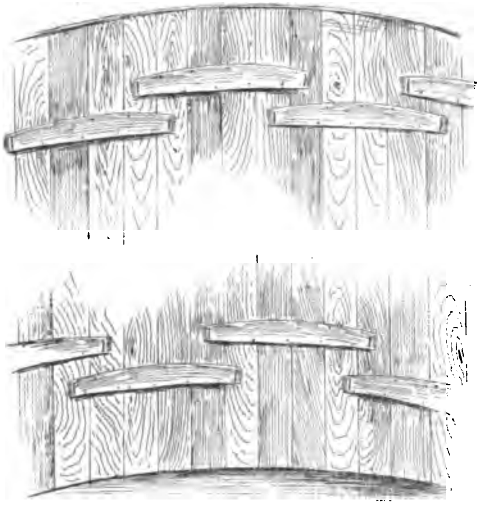


FIG. 78.—*Shows how barrel staves may be used in setting up a silo, they should be removed before the silo is filled.*

until the hoops are put in place. However, if it becomes necessary for any reason to delay for any considerable time the putting on of the hoops, boards should be nailed across the top of the silo. These will serve as braces and will enable the silo to resist wind storms of considerable violence without collapsing. As the staves are set up the level or plumb should be used occasionally to determine if they are being set vertically. The 6 x 6 posts mentioned as being first to be set in place are not a necessity, they are a convenience. Where a silo is being erected away from any other building these posts furnish the fixed points and assist in giving stability to the structure. When the roof is put on they will also be found of material benefit. If the silo is set up inside of the barn or in close proximity to the barn or other building, the first staves set up may be braced from the building. After a few staves are in place plank may be nailed across the top and thus a platform secured upon which a man can work. Unless some better method for securing the scaffolding can be devised the use of the uprights as shown in fig. 77 will be found valuable.

Splicing the staves.—If it is desired to build a silo 24 to 30 feet or more in height, it will often be found impracticable if not impossible, to secure staves the full length desired. Where this is the case a joint or splice may be made. For a silo 30 feet deep staves 20 feet in length may be used. A part of these should be used at their full length and part should be sawed through the middle, thus making staves of 20 and 10 feet length. In setting them up the ends which meet at the splice should be squared and toe nailed securely together. They should alternate so that first a long stave is at the bottom then a short one, thus breaking joints at 10 feet and 20 feet from the base. This breaking joints is preferable to having the joint come in a circle entirely around the silo, as it gives additional strength. Care needs to be exercised that the ends are made square, otherwise the air will be admitted.

Hoops for the stave silo.—The hoops for the stave silo are usually made from five-eighths inch round iron or steel rods. Cheaper substitutes have been used and given good satisfaction. The frontispiece shows a silo erected at Cornell University in which common woven wire fencing was made to serve as hoops. When the large stave silo inside the barn was filled it was found that more room was needed in which to store the corn crop. This was obtained by constructing a small silo 24 feet high and 12 feet in diameter, which was set up in a day and hoops of fence wire were put on and secured as shown in frontispiece. The staves were of 2x6 hemlock, 24 feet long, with edges neither matched nor bevelled. The silo was filled directly after completion and was satisfactory in every way.

Where the round hoops are used it is well to have each hoop in from three to four sections. For a silo 12 feet in diameter three sections will be sufficient, while for a silo 16 feet or more in diameter the hoops will handle more conveniently if they are in four sections each. If the method of construction shown in figure 77 is followed, then the hoops will need to be in four sections each, the ends being passed through the upright 6x6 posts and secured by heavy washers and nuts. A chisel should be used to sink one edge of the washer slightly so that the strain upon the nut will be squarely in line with the direction of the pull. If the upright posts are not used then a convenient way to secure the hoops is by means of the cast iron lugs as shown in fig 79. The hoops should be long enough so that they can be let out if it becomes necessary after the silo is filled and the strain becomes great. If when the hoops are tightened it is found that the thread at the end has not been made sufficiently long, pieces of gas pipe may be used as washers with which to take up the slack.

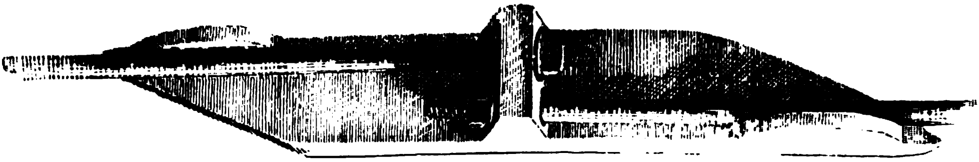


FIG. 79.—*Shows how the ends of hoops may be secured.*

The bottom hoop should be about six inches from the base of the silo; the second hoop should be not more than two feet from the first; the third hoop two and one-half feet from the second, the distance between hoops being increased by one-half foot until they are three and one-half feet apart, which distance should be maintained except for the hoops at the top of the silo which may be four feet apart. The hoops should be drawn fairly tight before the silo is filled but not perfectly tight. They must be tight enough to close up the space between the staves thus preventing any foreign matter from getting into the cracks which would prevent the staves from closing up as they swell, thus allowing air to enter. To hold both the hoops and the staves in place during the summer when the silo is empty, staples should be driven over the hoops into the staves. If a sufficient number of staples are used they will prevent the sagging or dropping down of the hoops and they will hold the staves securely in place.

The hoops should be watched very closely for a few days after the silo is filled. If the strain becomes quite intense the nuts should be slightly loosened. If during the summer when the silo is empty and the staves thoroughly dry the hoops are tightened so that the staves are drawn closely together, when the silo is filled and the wood absorbs moisture and begins to swell, the hoops must be eased somewhat to allow for the expansion. If a silo is constructed of thoroughly seasoned lumber and the hoops are drawn tight before filling, when the silo is filled the hoops must be loosened slightly or there is danger that the hoops will break or the thread will be stripped.

In one case a silo was allowed to dry out in the summer and fall down when by the use of staples or a few minutes spent in tightening the hoops, it might have been prevented. Another silo met with disaster due to the fact that the hoops were drawn perfectly tight on a dry silo and were not loosened when the silo was filled. The result was the hoops broke. A little judgment and care should be exercised with this as with all other farm operations.

Doors for the stave silo.—The doors should be located on the side of the silo most convenient for feeding. They may be in line, one directly above the other or they may be placed anywhere fancy or convenience dictates. If doors are placed one above the other the short pieces of staves should be well secured to the hoops by staples. The lower door should be between the second and third hoops at the bottom and other doors will usually be needed in every second space between there and the top except that no door will be needed in the top space as the silage when settled will be sufficiently low to enable it to be taken out at the door in the space below. Plans should be made for the doors at the time the staves are set. When the place is reached where it is desired to have the doors, a saw should be started in the edge of the stave at the points where the top and bottom of the doors are to come. The saw should be inserted so that the door can be sawed out on a bevel, making the opening larger on the inside of the silo. (See fig 80.) This will enable the door to be removed and put in place only from the inside and when set in

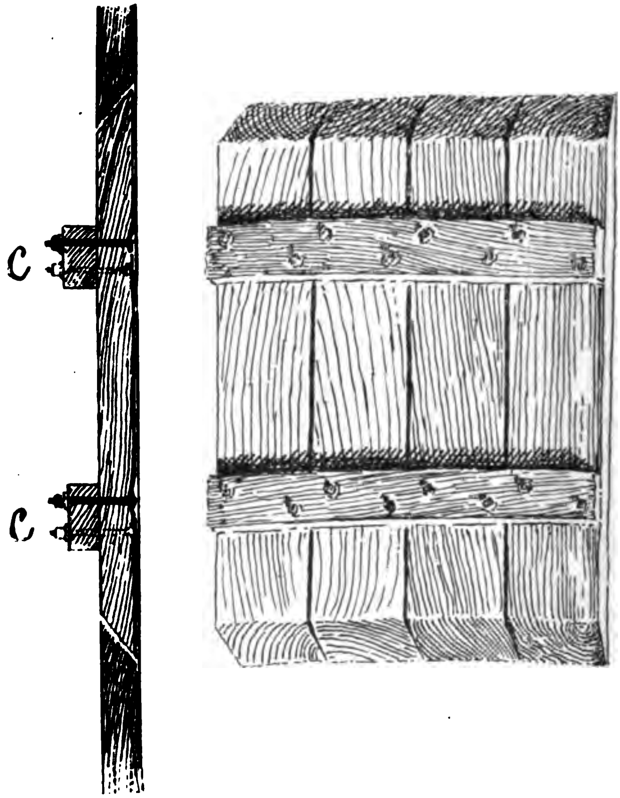


FIG. 80.—*Shows appearance of door after being sawed out, and shows side view of door in place. The cleates c. c. are on outside of door.*

place and pressed down with silage, the harder the pressure the tighter will the door fit. The sawing into the edge of the stave at this time is to permit the sawing out of the door after the staves are all in place without the necessity of making an auger hole, which would admit the air. After sawing into the edge of the stave deep enough to admit the end of the saw the stave

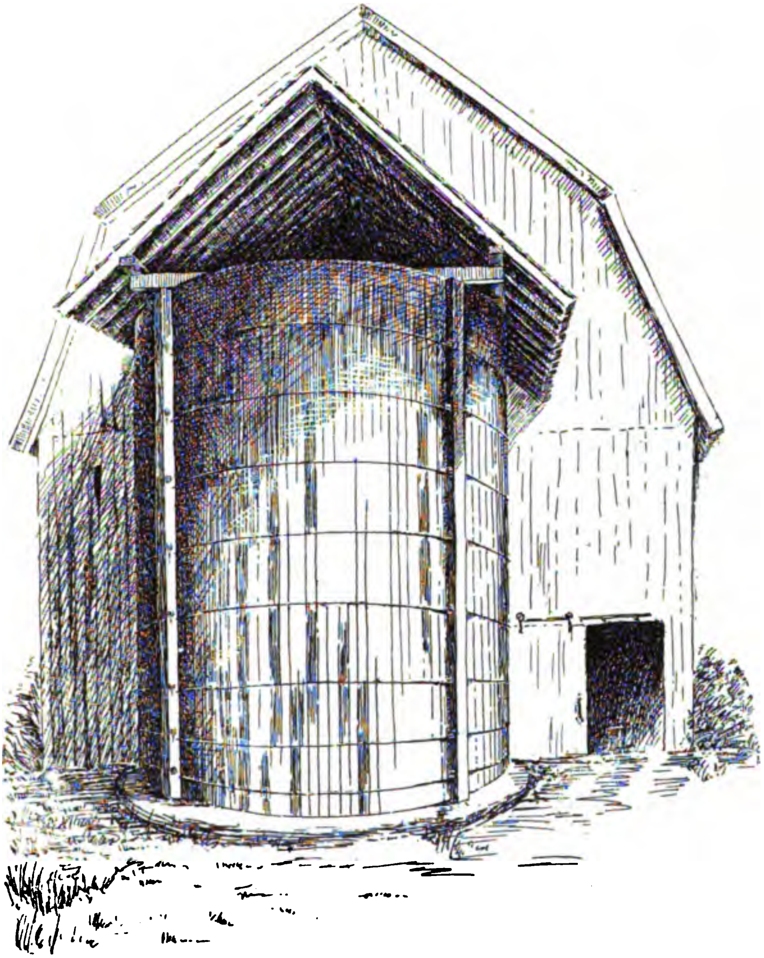


FIG. 81.—*Shows plan of Construction of Stave Silo.*

should be set in place so that the side corresponding to c. c. in fig. 80 shall be on the outside of the silo. After the silo is set up and the hoops have been put on and tightened the cutting out of the doors may be completed. The size of doors would better be two feet wide by about two and one-half feet long. This will allow the passing through of a large basket and will make a door of convenient size for handling. Before cutting out the doors cleats 2 inches by 3 inches and in length equal to the width of the door, should be made which will conform to the circular shape of the silo. One of these cleats should be securely bolted to the top and one to the bottom of where the door is to be cut. (See fig. 80.) After the bolting, the door may be sawed out and it is then ready for use. When set in place at time of filling the silo a piece of tarred paper inserted at the top and bottom will fill the opening made by the saw and prevent the entrance of any air around the door. Two silos built at Cornell University the past year had the doors constructed and put in, in the manner above described and not one pound of silage was wasted around doors.

The silo roof.—If constructed in the barn no roof or covering of any kind will be needed. If constructed out of doors some kind of roof should be provided. If the method of construction shown in fig 77 is followed, and the upright 6x6 posts are used, these posts may serve as supports for the plates upon which the rafters are to rest. The roof should have a sufficiently wide projection to protect as thoroughly as may be the walls of the silo from the elements. The plan of roof construction which will prove efficient is shown in fig 81. It is not necessary that the structure be air tight above the circular part. The gable end which is shown as open in the figure, may be boarded up. In this gable end a door should be provided through which the silo can be filled. The roof should extend from the silo to the barn so as to cover the space which intervenes, and thus afford protection to the feeder in stormy weather. Another way in which the roof may be put on is shown in the frontispiece. Around the top of the silo was bent and nailed one-half inch Georgia pine. This was put on so that a slight slope was given to the roof boards which simply overlap each other. The roof answered every purpose. Another form of roof which is now doing service over a silo 16 feet in diameter by 24 feet deep is shown in fig 82.

This silo was constructed in Tompkins County in the summer of 1898. No roof was put on until after the silo was filled.

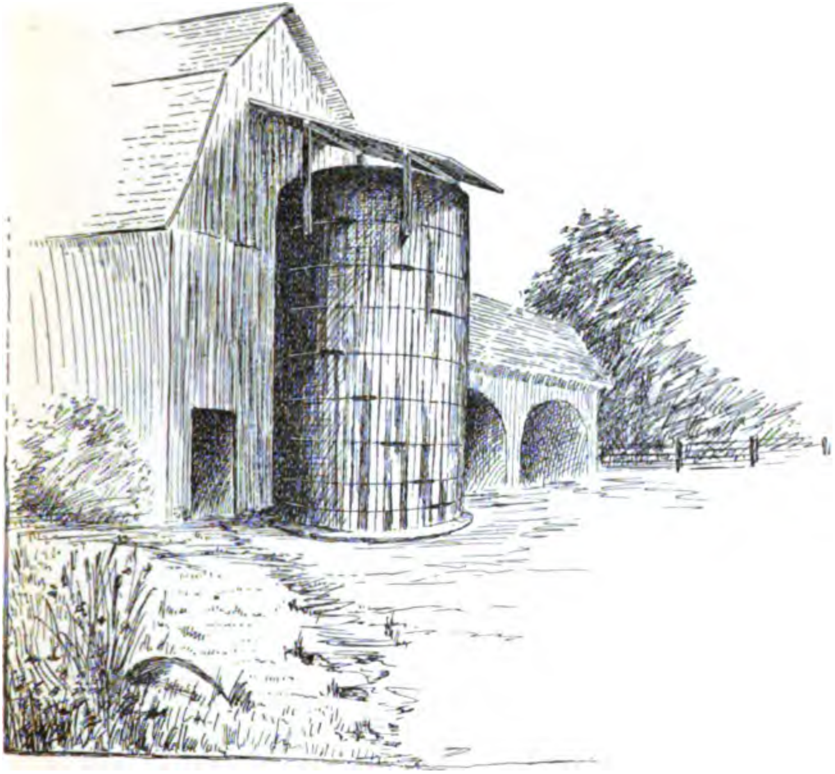


FIG. 82.—*Shows a roof which is doing good service.*

Then pieces of 2 x 4 scantling were nailed to the staves, plates were laid across the top and the roof supported as shown in the figure. The silage in this silo when examined in February directly after the temperature had been at zero for several days, and some of the time as low as 20° below zero, was found to be in most excellent condition. It was frozen around the edge next to the staves, but the frost had not penetrated for more than six inches. The top of the silage had been covered over with a foot or more of buckwheat straw and this protected the silage from action of frost. Samples of the frozen silage were taken and when thawed out no deterioration in value was observed. When these silos are constructed out of doors it is considered important that in cold weather the top of the silage be well covered over with straw or hay, or some other material which will conserve the heat from the interior. The covering can be pitched back each day as the silage is removed for feeding and then returned to place again. This practice successfully protected silage during the most severe weather that has been experienced in New York for many years.

Painting the silo.—Whether the silo shall be painted on the outside is simply a matter of taste. If the other farm buildings are painted it would be well to have the silo painted the same as the other buildings. Various paints and compounds have been recommended for the interior. Probably the best paint is common gas or coal tar put on hot, though it is very doubtful if the interior is improved by painting. If paint is applied to the staves while they are still green it is likely to hasten rather than prevent decay. If gas tar or paint is applied it should be done after the hoops are made tight and the staves drawn close, otherwise the paint is likely to enter the cracks and harden and thus prevent the staves from being drawn together. The large silo built at Cornell University was painted upon the interior,a part with gas tar and a part with a special preparation, and one part was left with no paint, the silage kept equally well in all portions of the silo.

It is impossible to anticipate all difficulties which will be met with in various cases. Ingenuity and judgment will suggest many changes from the plans which have been outlined above. It is hoped, however, that the suggestions herein contained will be of value to those who contemplate building a silo, and it is possible that the attention of some will be called to the feasibility and value of the silo who have not heretofore given the subject serious thought.

L. A. CLINTON.

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JUN 2 1899

Bulletin 168. **May, 1899.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

BOTANICAL DIVISION.

Studies and Illustrations
OF
MUSHROOMS: II.

"By the rose flesh mushrooms, undivulged
Last evening. Nay, in to-day's first dew
Yon sudden coral nipple bulged,
Where a freaked, fawn-colored, flaky crew
Of toadstools peep indulged."
Browning's By the Fireside.

THREE EDIBLE SPECIES OF COPRINUS.

By GEO. F. ATKINSON.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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CORNELL UNIVERSITY, ITHACA, May 15, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY, N. Y.

Sir: This bulletin, the second of a series of "Studies and Illustrations of Mushrooms," is submitted under Chapter 67 of the Laws of 1898. The object of these studies is to give accurate information upon, and illustrations of, the more common mushrooms or toad-stools. This should enable interested persons to collect and determine specimens occurring from spring to late autumn. Large numbers of the edible species go to waste each year for the want of some clear and ready information to assist in distinguishing the edible from the poisonous kinds.

It is to be regretted that in the smaller cities, in suburban districts, and upon the farms, more attention is not given to learning to know *well* a few of the more common species, since the fields and woods where these plants grow are so easy of access. By careful attention to the localities and by comparison of the plants with the descriptions and illustrations given in these bulletins, a person having no botanical knowledge can identify a number of these plants. Every one has, or should have, a certain amount of leisure time which can be devoted to recreation, or relief from the every day work. Many find enjoyment and profit in combining such recreation with an interest in some observation upon nature and natural objects. Having learned to recognize the edible species, it is possible thereafter to readily collect for food large numbers of the more common ones. Some of these plants are so easily determined that children only eight years old, after seeing the photographs of two of the species illustrated in this bulletin, were able later to name the plants from freshly collected specimens, without the opportunity of a comparison with the photographs.

One not familiar with the subject should use caution in the first collections of an unknown plant. It is well in some cases to consult some one who does know the plants, or who has the means of determining them. In such cases, the Botanical Division of this Station is ready to assist in the identification. Directions for collecting and mailing specimens are given in the present bulletin. With some attention to this subject there is no reason why, in America, mushrooms should not form as important an article of food as they do in parts of the Old World.

Professor Atkinson has made a large number of photographs of the edible and poisonous mushrooms, as well as of those wood destroying species so destructive to timber and forest trees.

I. P. ROBERTS, Director.

STUDIES AND ILLUSTRATIONS OF MUSHROOMS, II.

Three Edible Species of Coprinus.

I—The Shaggy-Mane (*Coprinus comatus*).

The "shaggy-mane," or "horsetail mushroom" (Coprinus comatus), is one of the largest plants of this genus. It is usually considered by many to surpass all the other species of the genus in those qualities most esteemed by the fungus eater. The frontispiece is from a photograph of a group of these plants growing in a lawn on the Cornell University Campus. All stages of the "horsetail" are here represented, from the tiny ones which are thrusting their heads through the turf to the old ones which present an unsightly aspect as they are melting down into inky blackness, an example of the swiftness with which it passes its ephemeral existence. A day, or at most two or three days is vouchsafed to it during which it is to lift itself up into the free air, where it may expand and mature its spores. Then it vanishes. But it has accomplished the final purpose for which it exists as an organism. Its "seed," the spores are free to be carried by the wind or other agencies of dissemination to distant places, and thus propagate the species. While the natural mode of the wide dissemination of the plant is probably by the distribution of the spores, dissemination may take place through the agency of man or other animals when the soil is disturbed.

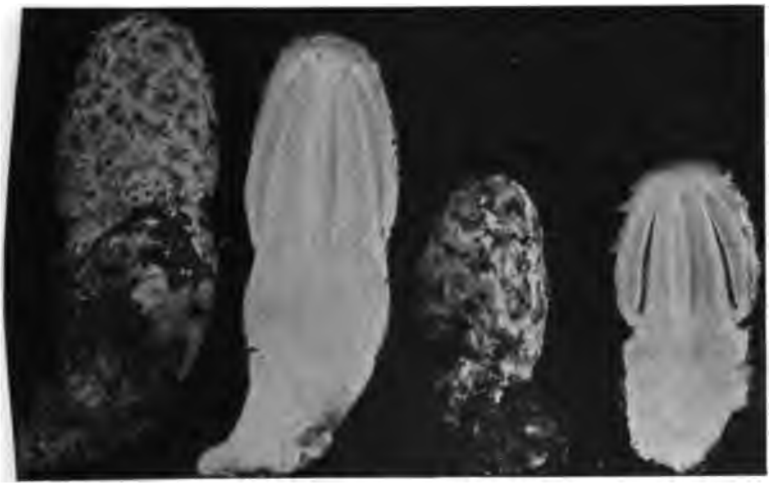
Some of the "spawn" may be transplanted in the sod for covering new lawns, or in the fertilizer for old ones. Here food lying hidden in the soil is awaiting forage at the pleasure of the searching threads of the mycelium or "spawn," which now spreads its meshes as it extends through the earth. Here it grows for months or sometimes for years may be, laying by supplies in the shape of an increased amount of "spawn." We tread upon the soft carpet of green or recline on the sod unmindful of the process of growth, absorption and assimilation in that wonderful unseen world of plant life. Suddenly some morning we see the shaggy, unkempt heads of our old friends again just risen from their long sleep which calls to mind Browning's verse,—

> "By the rose flesh mushrooms undivulged
> Last evening. Nay, in to-day's first dew
> Yon sudden coral nipple bulged,
> Where a freaked, fawn-colored flaky crew
> Of toad-stools peep indulged."

83.—"*Shaggy-mane*" (*Coprinus comatus*) *in lawn.*

A "mushroom growth," we say. It looks that way; as if the whole thing had grown in a single night. That is because we have not searched underneath the sod and observed the long, tedious process of growth while the cords and meshes of the mycelium have increased, and extended their lines through the moist soil. If we do search there and observe we see that sometime before the shaggy heads peep forth, tiny bodies appear on the cords of mycelium; first like a pin head in size, then as large as a pea and the size of a thimble they grow. A great deal of growth has taken place in the formation of these tiny bodies beneath the soil. They are made up of delicate threads and the tiniest cells which have multiplied until there are countless numbers of them. Now when every thing is ready in these fungus "buttons," the tiny cells already formed, as well as new ones still forming, expand rapidly and this pushes the mushroom up into view in a single night.

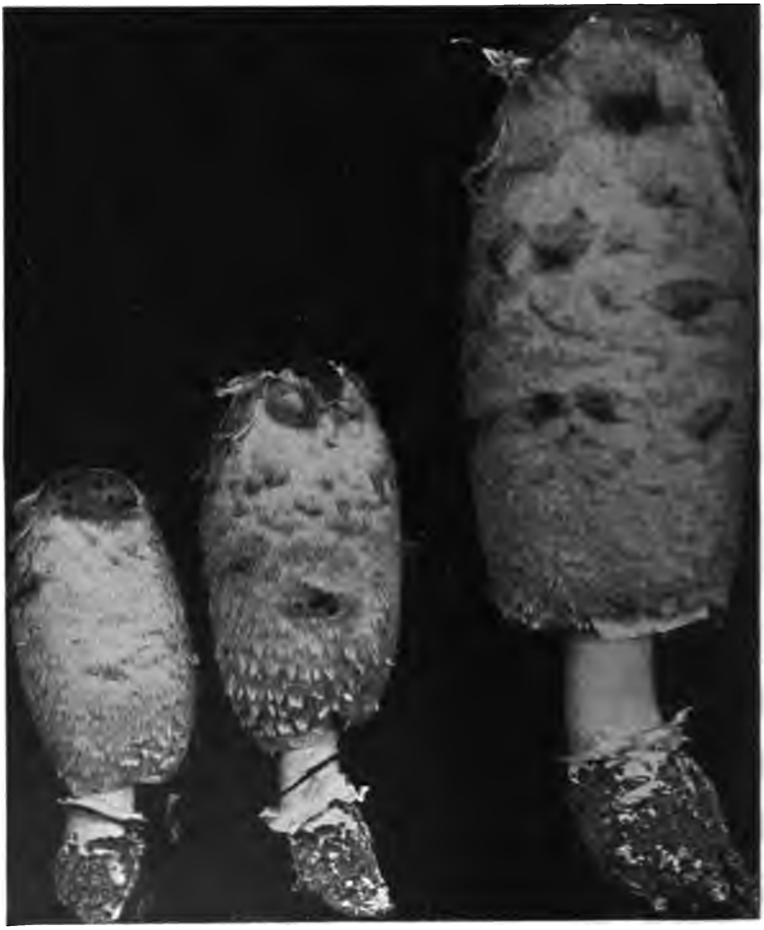
In figure 84 are shown two buttons of the size when they are just ready to break through the soil. They are now quite dark



84.—"*Buttons*" *of Coprinus; two in section, showing gill slits and hollow stem.* (*Natural size.*)

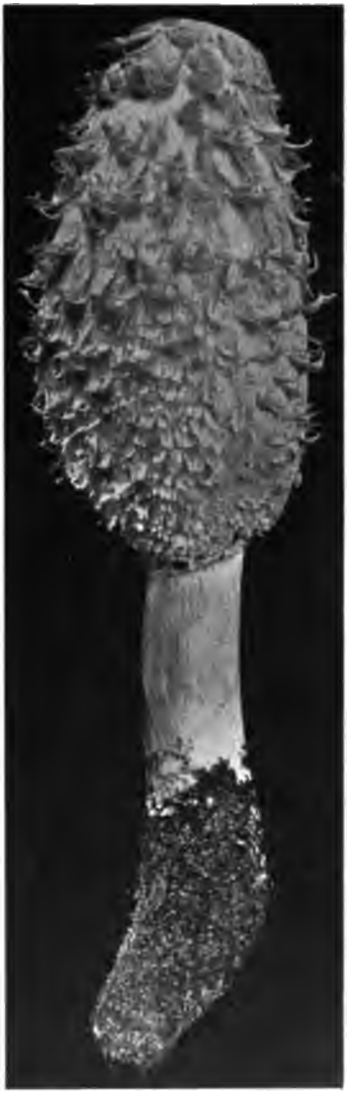
in color on the outside. They appear mottled with dark and white, for the outer layer of fungus threads, which are dark brown, is torn and separated into patches or scales, showing between, the delicate meshes of white threads which lie beneath. The upper part of the button is already forming the cap or "pileus," and the slight constriction about midway shows the lower boundary or margin of the pileus where it is still connected with the undeveloped stem.

We are curious to know if the internal structure of these buttons will reveal the parts of the mushroom. We can learn this by splitting buttons through from one end to the other with a sharp knife. At the right of each of these buttons in the figure is shown a section of a plant of the same age. Here the parts of the plant though still undeveloped are quite well marked out. Just underneath the pileus layer are the gills. In the section one gill is exposed to view on either side. They are long, narrow, and taper at each end. In the section of the larger button the free edge of the gill is still closely applied to the stem, while in



85.—*Coprinus comatus, removed from soil.* (*Natural size.*)

the small one the gills are separated a short distance from the stems showing "gill slits." Here, too, the connection of the margin of the pileus with the stem is still shown. From our first study of mushrooms (Bulletin 138) we know that this connecting layer between the margin of the pileus and stem forms the veil. This kind of a veil is a marginal veil.

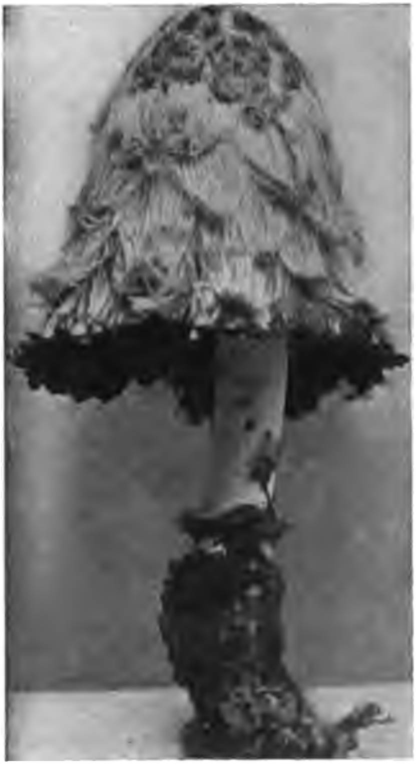


86.—*Coprinus comatus, well meriting the name "shaggy mane"*. (*Natural size.*)

The stem is hollow even at this young stage, and a slender cord of mycelium extends down the center of the tube thus formed as is shown in the sections. From the button stage the growth is quite rapid, and in a short while the plants are full grown.

Now the plants are nearly all white. The brown scales so close together on the buttons are widely separated except at the top or center of the pileus, where they remain close together and form a broad cap resting jauntily on the shaggy head. This is shown in figure 85 which is from a photograph of three plants removed from the sod.

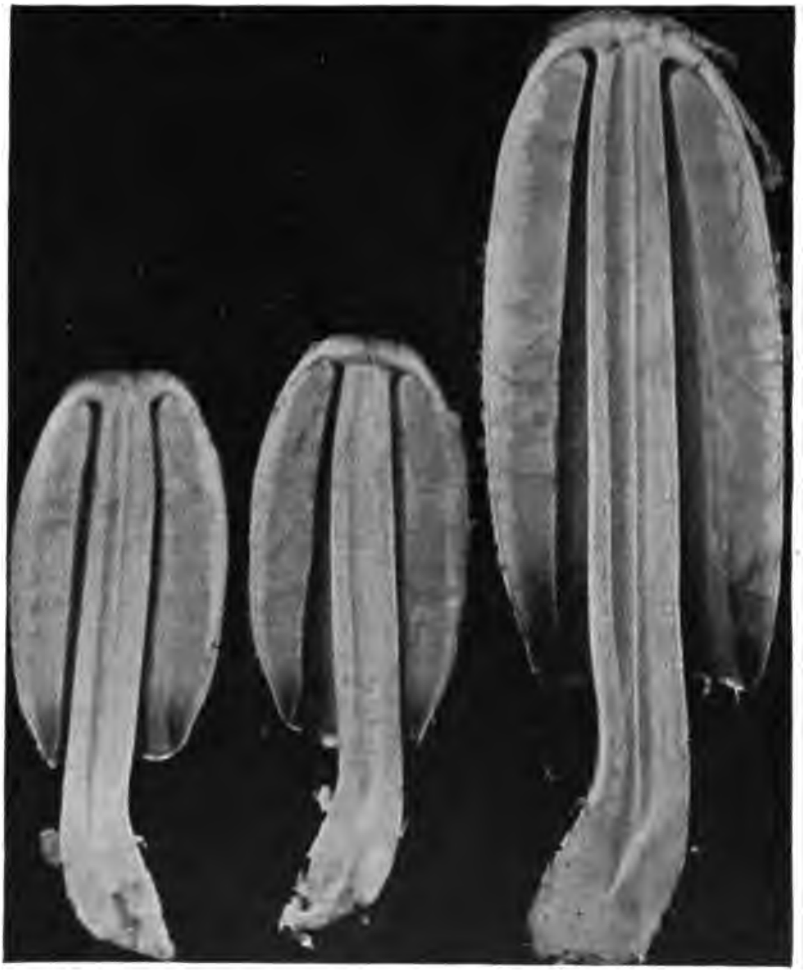
A study of the different stages, which appear from the button stage to the mature plant, reveals the cause of this change in color and the wide separation of the dark brown scales. The threads of the outer layer of the pileus, and especially those in the brown patches seen on the buttons, soon cease to grow, though they are firmly entangled with the inner layers. Now the threads underneath and all through the plant, in the gills and in the upper part of the stem grow and elongate rapidly. This pulls on the outer layer tearing it in the first place into small patches and causing them later to be more widely separated on the mature plant. Some of these scales remain quite large while others are torn up into quite small tufts.



87.—*Coprinus comatus, surface of pileus gathered in loups.* (*Natural size*).

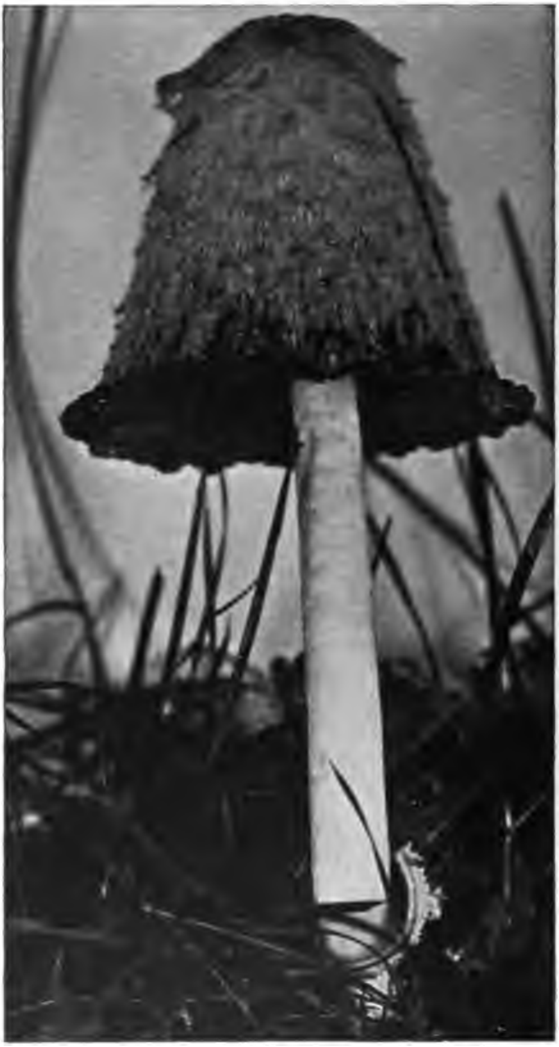
As the plant ages, the next inner layers of the pileus grow less rapidly, so that the white layer beneath the brown is torn up into an intricate tangle of locks and tufts, or is frazzled into a delicate pile which exists here and there between well formed tufts. While all present the same general characters there is considerable individual variation as one can see by comparing a number of different plants. Figure 86 shows one of the interesting conditions. There is little of the brown color, and the outer portion of the pileus is torn into long locks, quite evenly distributed and curled up at the ends in an interesting fashion which merits well the term "shaggy." In others the threads are looped up quite regularly into triangular tresses which appear to be knotted at the ends where the tangle of brown threads holds them together as if some fairy had plaited the lock.

There is one curious feature about the expansion of the pileus of the shaggy-mane which could not escape our attention. The pileus has become very long while comparatively little lateral expansion has taken place. The pileus has remained cylindrical or barrel-shaped, while in the case of the mushrooms treated of in our first study the pileus expanded into the form of an umbrella.



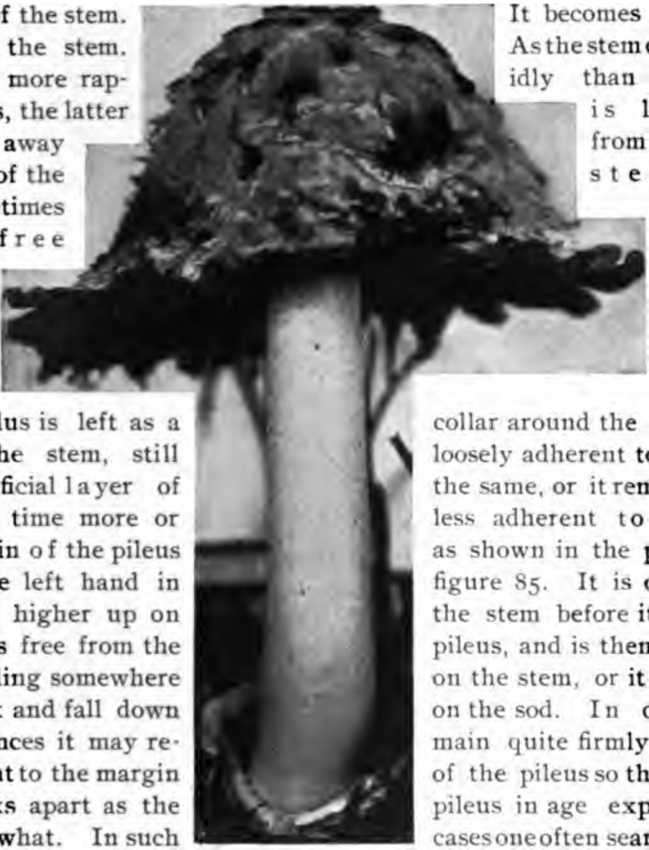
88.—*Coprinus comatus, sections of the three plants shown in figure 85.* (*Natural size*).

The cylindrical or barrel-shaped pileus is characteristic of the shaggy-mane mushroom. As the pileus elongates the stem does also, but more rapidly. This tears apart the connection of the margin of the pileus with the base of the stem, as is plainly shown in figure 85. In breaking away, the connecting portion or veil, is freed both from the stem and from the margin of the pileus, and is left as a free, or loose ring, around the stem. In all of the plants of our former study, the common mushroom (*Agaricus campestris*), the smooth lepiota (*Lepiota naucina*), and the deadly amanita (*Amanita phalloides*), the ring remained attached to the stem, *i. e.*, it is not a free ring in those



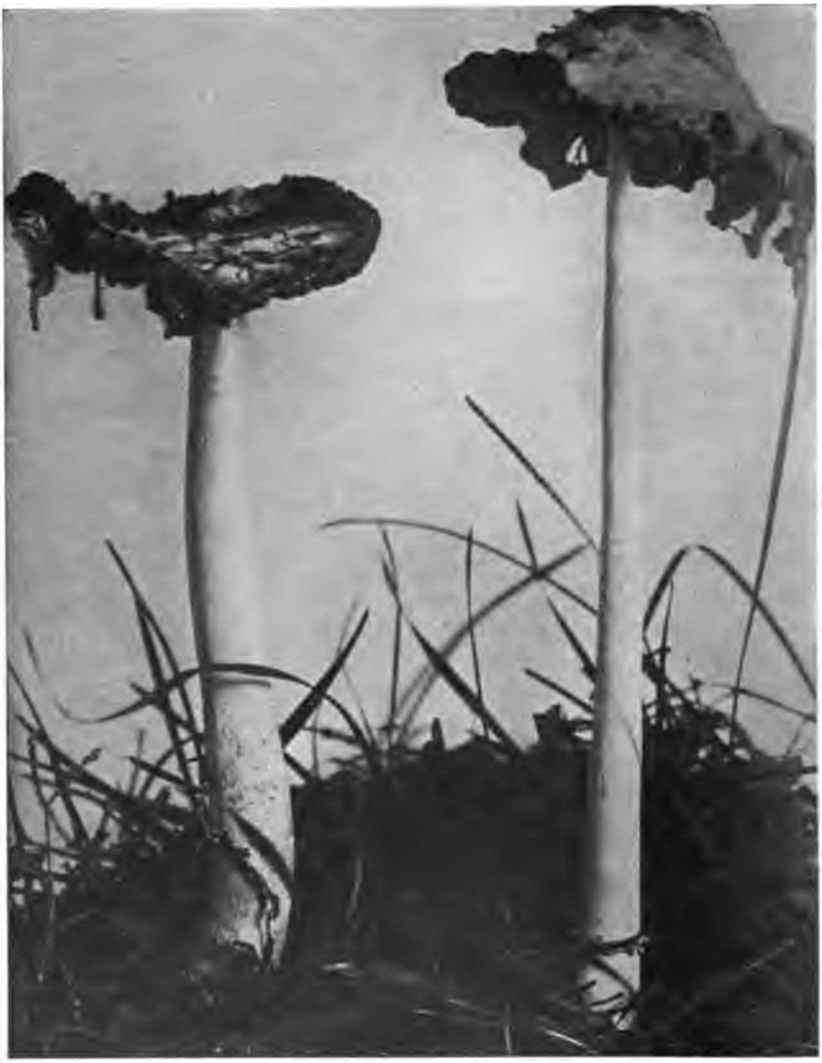
89.—*Coprinus comatus, early stage of diliquescence. The ring is lying on the sod. (Natural size.)*

species. In the shaggy-mane the veil does not form a thin expanded curtain as in the three species just enumerated. It is really an annular outer layer of the button lying between the margin of the pileus and the base of the stem. It becomes free from the stem. As the stem elongates more rapidly than the pileus, the latter is lifted up away from the base of the stem. Sometimes the free annulus is left as a collar around the base of the stem, still loosely adherent to the superficial layer of the same, or it remains for a time more or less adherent to the margin of the pileus as shown in the plant at the left hand in figure 85. It is often lifted higher up on the stem before it becomes free from the pileus, and is then left dangling somewhere on the stem, or it may break and fall down on the sod. In other instances it may remain quite firmly adherent to the margin of the pileus so that it breaks apart as the pileus in age expands somewhat. In such cases one often searches for some time to discover it clinging as a sterile margin of the pileus, so closely does its outer texture resemble the outer texture of the pileus. It is interesting to observe a section of the plants at this stage. These sections can be made by splitting the pileus and stem lengthwise through the middle line with a sharp knife as shown in figure 88. Here, in



90.—*Coprinus comatus, later stage of deliquescence, pileus becoming more expanded.* (*Natural size*).

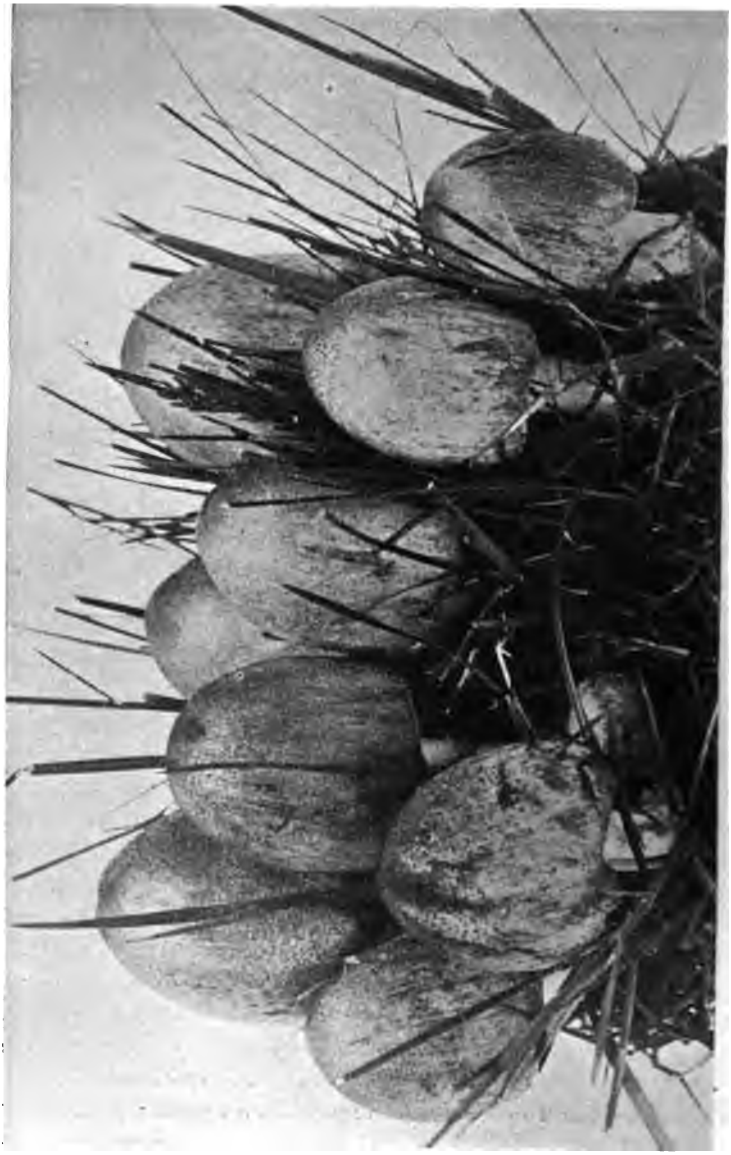
the plant at the right hand, the "cord" of mycelium is plainly seen running through the hollow stem. This cord is well seen



91.—*Coprinus comatus, drops of inky fluid about to fall from wasted pileus.* (*Nutural size*).

if one partly splits a stem and then gently pulls the halves apart. At the same time if the stem is held toward the light a very delicate mesh of threads, reminding one of the finest gauze, is seen extending from the cord to the wall of the tubular stem. The gills form a large portion of the plant for they are very broad and lie closely packed side by side. They are nowhere attached to the stem but at the upper end round off to the pileus leaving a well defined space between their ends and the stem. The pileus, while it is rather thick at the center, *i. e.*, where it joins the stem, becomes comparatively thin where it spreads out over the gills. At this age of the plant the gills are of a rich salmon color, *i. e.*, before the spores are ripe, and the taste when raw is a pleasant nutty flavor reminding one of the meat of fresh green hickory nuts. In a somewhat earlier stage the edges of all the gills are closely applied to the stem which they surround. So closely are they applied to the stem in most cases that threads of mycelium pass from the stem to the edge of the gills, so that they might be said to be "sewed" together. As the pileus expands slightly in ageing, these threads are torn asunder and the stem is covered with a very delicate down or with flocculent particles which easily disappear on handling or by the washing of the rains. The edges of the gills are also left in a frazzled condition as one can see by examining them with a good hand lens.

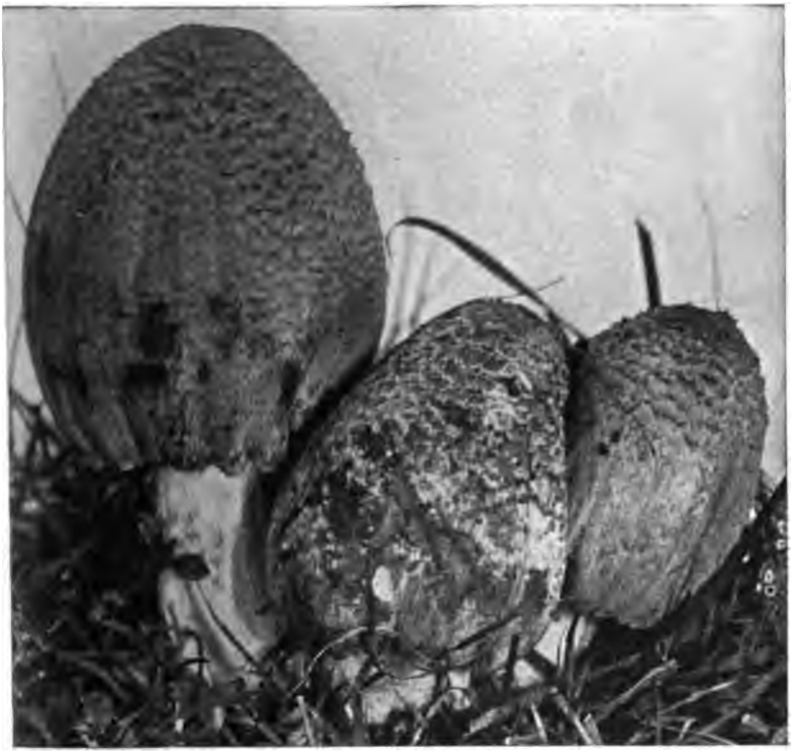
The spores now begin to ripen and as they become black the color of the gills changes. At the same time the gills and the pileus begin to dissolve into an inky fluid, first becoming dark and then melting into a black liquid. As this accumulates it forms into drops which dangle from the pileus until they fall away. This change takes place on the margin of the pileus first, and advances toward the center, and the contrast of color, as the blackening invades the rich salmon, is very striking. The pileus now begins to expand outward more, so that it becomes somewhat umbrella shaped. The extreme outer surface of the pileus does not diliquesce so freely, and the thin remnant curls upward and becomes enrolled on the upper side as the pileus with wasted gills becomes nearly flat.



92.—*The "ink-cap", Coprinus atramentarius, nearly smooth form. (Natural size).*

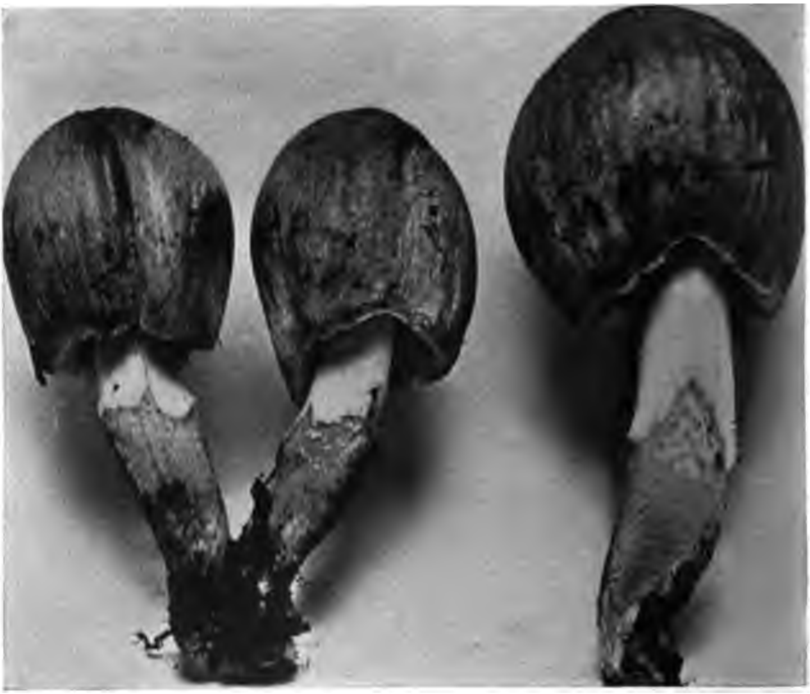
II.—THE INK-CAP (*Coprinus atramentarius*).

The ink-cap (*Coprinus atramentarius*) occurs under much the same conditions as the shaggy-mane, and is sometimes found accompanying it. It is usually more common and more abundant. It springs up in old or newly made lawns which have been richly manured, or it occurs in other grassy places. Sometimes the plants are scattered, sometimes two or three in a cluster, but usually large clusters are formed where ten to twenty or more are crowded closely together (figure 92). The stems are shorter than those of the shaggy-mane and the pileus is of a different shape and color. The pileus is more egg-shaped or oval. It



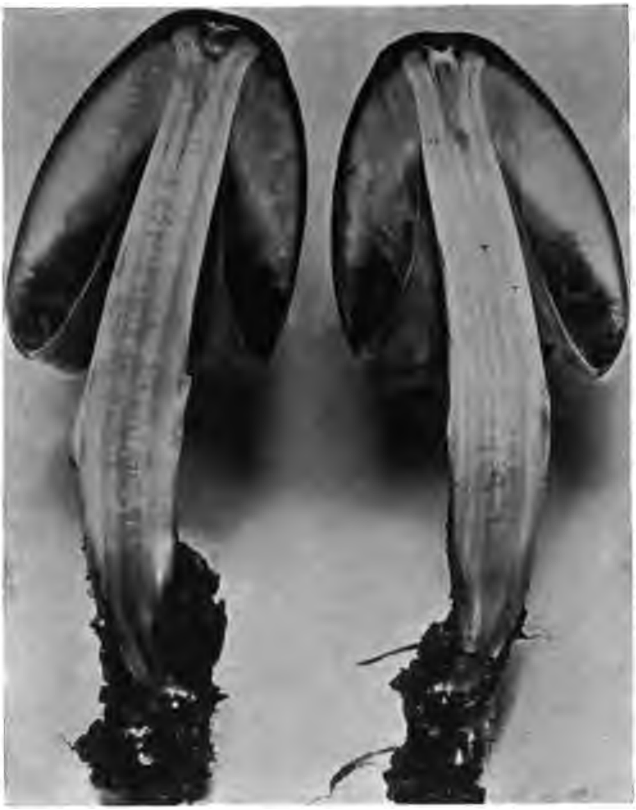
93.—*Coprinus atramentarius, scaly form.* (*Natural size.*)

varies in color from a silvery grey in a few forms, to a dark ashen grey, or smoky brown color in others. Sometimes the pileus is entirely smooth, as I have seen it in some of the silvery grey forms, where the delicate fibres coursing down in lines on the outer surface cast a beautiful silvery sheen in the light. Other forms present numerous small scales on the top or center of the pileus which are formed by the cleavage of the outer surface here into large numbers of pointed tufts. In others, the delicate tufts cover more or less the entire surface, giving the plant a coarsely granular aspect. This is perhaps the more common appearance, at least so far as my observation goes. But not infrequently one finds forms which have the entire outer surface



94.—*Coprinus atramentarius; showing annulus as a border line between scaly and smooth part of stem.* (*Natural size.*)

of the pileus torn into quite a large number of coarse scales, and these are often more prominent over the upper portion. Fine lines or striations mark also the surface of all the forms, especially toward the margin where the scales are not so prominent. The marginal half of the pileus is also frequently furrowed more or less irregularly, and this forms a crenate or uneven edge.

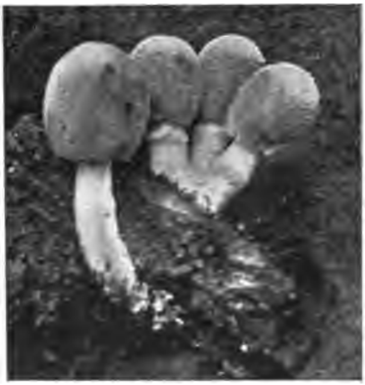


95.—*Coprinus atramentarius, section plant.* (*Natural size.*)

The annulus or ring on the stem of the ink-cap is very different from that of the shaggy-mane. It forms an irregularly zigzag elevated line of threads which extend around the stem near the base. It is well shown in figure 94 as a border line between the lower scaly end of the stem and the smooth white upper part. It is formed at the time of the separation of the margin of the pileus from the stem, the connecting fibres being pulled outward and left to mark the line of junction, while others below give the scaly appearance. It is easily effaced by rough handling or by the washing of the rains. A section of a plant is illustrated by a photograph in figure 95. On either side of the stem is shown the layer of fibres which form the annulus, and this layer is of a different texture from that of the stem. The stem is hollow as seen here also. In this figure one can see the change in color of the gills just at the time when they begin to diliquesce. This diliquescence proceeds much in the same way as in the shaggy-mane, and sometimes the thin remnant of the pileus expands and the margin is inrolled over the top.

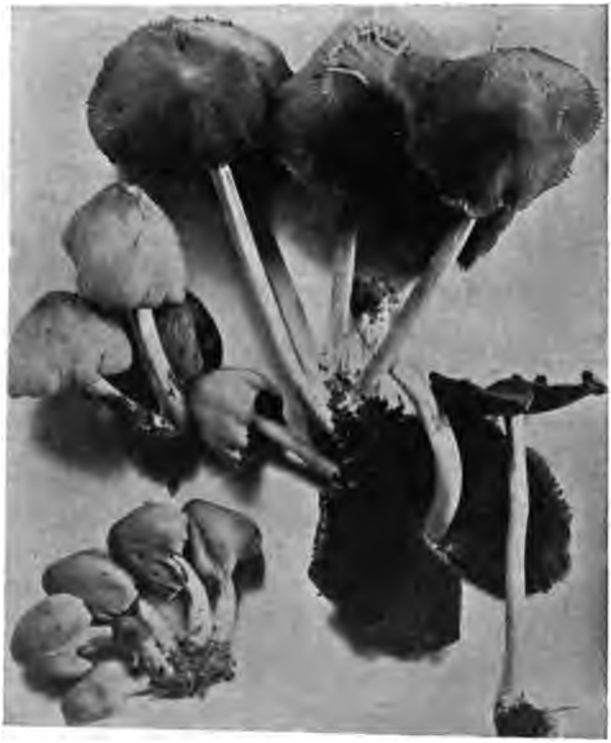
III.—THE GLISTENING COPRINUS (*Coprinus micaceus*).

The third species described here is the glistening coprinus (*Coprinus micaceus*). It received this name because of the very delicate scales which often cover the surface of the pileus, and glisten in the light like particles of mica. This plant is very common during the spring and early summer though it does appear during the autumn. It occurs about the bases of stumps or trees or in grassy or denuded places, from dead roots, etc., buried in the soil. It occurs in dense tufts of ten to thirty or more individuals ; sometimes as many as several hundred spring up from the roots of a dead tree or stump along the streets or in lawns, forming large masses. More rarely it occurs on logs in the woods, and sometimes, the plants are scattered in lawns. From the different habits of the plant it



96.—*The "glistening coprinus," Coprinus micaceus; young stage showing annulus, on the pileus the "mica" particles. (Natural size.)*

is sometimes difficult to determine, especially where the individuals are more or less scattered. However, the color of the plant, and the markings on the pileus, especially the presence of the small shining scales when not effaced, characterize the plant so that little difficulty is experienced in determining it when one has once carefully noted these peculiarities.



97.—*Coprinus micaceus, showing different aspects.*
(2-3 natural size.)

Figure 96 is from a group of three young individuals photographed just as the margin of the pileus is breaking away from the lower part of the stem, showing the delicate fibrous ring which is formed in the same way as in Coprinus atramentarius. The ring is much more delicate and is rarely seen except in very young specimens which are carefully collected and which have not been washed by rains. The mature plants are 8 cm. to 10 cm. high (3–4 inches), and the pileus varies from 2 cm. to 4 cm. in diameter. The stem is quite slender and the pileus and gills quite thin as compared with the shaggy-mane and ink-cap. The gills are not nearly so crowded as they are in the two other species. The pileus is tan color, or light buff, or yellowish brown. Except near the center it is marked with quite prominent striations which radiate to the margin. These striations are minute furrows or depressed lines, and form one of the characters of the species, being much more prominent than on the pileus of the ink-cap.

In wet weather this coprinus melts down into an inky fluid also, but in quite dry weather it remains more or less firm, and sometimes it does not diliquesce at all, but dries with all parts well preserved though much shrunken of course as is the case with all the very fleshy fungi.

Many persons who are fond of mushrooms do not venture to collect and eat other species then the *Agaricus campestris*. Many will tramp considerable distances to collect the "pink gilled agaric," and pass by on the street, or perhaps in their dooryard, a clump of coprinus sufficient for a meal. During the spring and early summer the *Agaricus campestris* is not to be had in the open, while these three species of coprinus usually, grow in abundance, though the shaggy-mane is usually more abundant in the autumn than in the spring.

During the autumn of 1898 the common "pink gilled mushroom" (*Agaricus campestris*) was very rare in the vicinity of Ithaca. This has led a few to search for other forms. Two of my friends during October brought into my office a peck basket filled with mushrooms, and wished to know if they were "good to eat." Nearly all of the plants were the "ink-cap" (*C. atramentarius*), there were four or five of the shaggy-mane (*C. comatus*), and a single "glistening coprinus" (*C. micaceus*). All of them good to eat and collected in a single dooryard. One of these gentlemen had never before ventured to partake of any other species than the *Agaricus campestris*.

During the early summer of 1897, while collecting a "mess" of *Coprinus micaceus* from a large tuft growing around the base of a stump on one of the principal streets of Ithaca, a passer-by halted, probably for the charitable purpose of giving some information which he thought might save my life. "Them's toad-stools ain't they?" "Yes," I replied. "Well, I thought so," said he. Thereupon I ate one of the "toad-stools" raw, and received from him a look of mingled pity and despair as he passed on.

All of these three species have a somewhat nutty flavor, that of fresh hickory nuts when eaten raw, but they are more palatable when properly prepared for the table. The *Coprinus micaceus* need only be rinsed to remove from the caps any adhering particles of soil. The other two species may be peeled if it is desired to remove the outer and tougher layer of the pileus, or this may be done by gently scraping. The shaggy-mane peels well by starting at the margin of the pileus and with the fingers stripping off the outer layer. The ink-cap peels more readily by first splitting the pileus in halves and then starting the strip at the top of each half. It is sufficient, however, to gently scrape the surface of the pileus to remove the coarser outer fibers and whatever soil may adhere.

To those who are not acquainted with any of the species of coprinus and wish to extend the range of species collected for table use these three species are commended. The shaggy-mane is perhaps the most delicious of the three, but the other two are much more abundant usually. By a careful comparison of the species growing in lawns, and along streets with these descriptions, and especially with the illustrations, there should be no trouble in identifying them. While the camera here has not at present succeeded in reproducing all the colors, this series of photographs illustrates well the habit, texture and specific characters of the plants, and the color values in black and white are quite faithfully represented. It is doubtful if any hand coloring has yet succeeded in producing such perfect imitations as these photographic studies of the shaggy-mane and ink-cap. That they accurately portray the habit and specific characters of these plants I am convinced by the experience of my little boy of eight years. While selecting the illustrations for this study one evening, I showed him the photographs, told him the names of each and the parts of the mushroom. The subject was not mentioned again until a week later when I brought in a few specimens of one of the species. "What is the name of this?" I said. "That's the shaggy-mane," he said. "What part is this?" "That's the cap." "And this?" That's the ring." "And this?" That's the stem." "Now, father," he said, "where's the ink-cap?" At another time he was able to select the ink-cap from among a miscellaneous collection.

While the *Coprinas micaceus* usually grows on decaying wood, or roots, etc., underneath the soil, the shaggy-mane and ink-cap grow in rich soil in grassy places, especially such as have been quite recently manured. This latter peculiarity of growing on manured ground, or on dung, so characteristic of a number of the species of the genus, suggested the name "*coprinus*," from the work "*kopros*," meaning dung.

A large number of the species of the genus, practically all the large fleshy ones (some of the smaller also) diliquesce into an inky fluid. In the delicate or membranous ones, usually quite small species, the pileus splits in radiating lines above each gill in such a way that the gill itself is split downward, thus giving to the pileus a fluted appearance.

In bulletin 138 the writer suggested the formation of mycological clubs as a medium for the exchange of information among interested persons in a given community. At that time there was already in existence among others, the Boston Mycological Club, New York Mycological Club and the Philadelphia Mycological Center. Since that time there have been organized the Washington Mycological Club, Chicago Mycological Club, and others.

CORNELL MYCOLOGICAL CLUB.

A mycological club has recently been organized at Cornell University, with a somewhat broader work in view. It is called the "Cornell Mycological Club" and is under the supervision of the members in the Botanical Department. Its purpose is to study the fungi, to propagate information concerning them among its members, and to encourage the growing popular interest in those groups of economic importance, to which belong especially the edible, poisonous and parasitic fungi.

The rules governing the club are such that they admit to membership any person interested in its aims and work. No other qualifications except the payment of the small annual fee of twenty-five cents, are necessary, and any person sending name and enclosing the fee will be placed on the membership roll. This small fee is to be used in necessary expenses incurred relating to executive matters of the club, as determined by the Executive Council. With this small fee it will not be possible at present to publish a bulletin of information. It is hoped, however, that it will lead eventually to some medium of communication among members, by which a knowledge of the numerous local fungus floras may be obtained, and that this information as well as other matters of interest may be regularly communicated to members.

It is purposed to make the club a center to which persons interested in the study, and in becoming acquainted with the fungi, may appeal for aid in the determination of species they collect. To this end a few general directions are given here for those who desire to know how to put up specimens properly for mailing, so that they will not be broken or ruined in transit.

HOW TO MAIL FLESHY FUNGI.

Fresh "mushrooms," or "toad-stools" if of medium or large size, should be wrapped separately in tissue paper, or if the plants grow in tufts the paper can be worked in between the individual specimens unless the tuft is a compact one. A sufficient amount of paper should be used to give support to the expanded parts of the plant, and so arranged that delicate structures on the surface will not be rubbed away. The plants should then be packed quite firmly, but not crushed, into a tin box, or a light but strong wooden box. If they do not quite fill it more paper can be added, so that they will not jostle about, or they become badly broken. Pasteboard boxes are apt to become broken and ruin the specimens.

In collecting the mushrooms do not break off the stems, but pry the stems out of the earth carefully in order to preserve all the characters on the lower end of the stem. Also use care in handling the stems so that the "collar," when present, and the delicate scales, be not rubbed off. The corky or woody fungi growing on trees, logs, stumps, etc., may be wrapped in the same way. In all specimens from logs or trees, the name of the wood should be given when that is accurately known. When the name of the tree is not known a portion of the wood and bark, or some leaves, may accompany the specimen. The corky or woody fungi may be dried before mailing if desired. To dry the fleshy fungi requires considerable care, and usually artificial heat, for they must be dried quickly, not burned or roasted, though careful notes upon the characters of the plants while fresh, should also be made before they are dried, in most cases.

An extemporized oven for drying may be made of tin, with holes in the sides for ventilation. In this the plants can be placed in paper boxes while they are drying. The oven may then be placed above a stove, or a lamp may be placed underneath it. Shelves above a stove where warm air is constantly rising is a good place to dry the plants. The best place that I have ever used is the brick work around a large steam boiler, the plants, or boxes containing them, being placed directly on the brick work. Parasitic fungi on leaves of plants should be dried between absorbent paper under some pressure to keep the leaves from shriveling and curling.

Dried specimens of the mushrooms can be wrapped in tissue paper for shipment. It is better in most cases, however, if the plants are shipped away for determination, to send them in a fresh condition. At least some duplicates are desirable in a fresh condition, since fresh material is often necessary for determination of the species, especially with doubtful species, and in the case of many genera.

When fresh material is mailed, if the sender will use foresight in putting it up and mailing just in time for a mail train which makes good connections through, specimens will usually travel several hundred miles and arrive in a good condition.

Specimens sent by mail require, according to the present postal regulations, 1 ct. per 2 ounces in weight, and the package should be marked "plants." Wherever it is desired to send by express, the sender should pay the express charges, except where good material prepared and named for the herbarium or museum is contributed, or where the sender is certain that the material is of value, as in the case of some rare specimens. In all cases where a list of the plants is desired in return, the sender should enclose a number with each specimen, so that the names can be given to correspond with the numbers. All desirable material will be preserved and kept in the herbarium here where it will be available for comparison and for study. For this reason the locality and date of collection and other notes of interest should accompany the specimens. After one has had some experience in the collection of these plants and in noting the important characters their specimens will be of more value. It is possible in this way for collectors to aid us in bringing together material from different sources which should assist in making these studies and illustrations of mushrooms more comprehensive and of wider usefulness.

From students of the fungi who have duplicate material in any of the groups, the Botanical Department will welcome contributions to the herbarium. Such gifts are certain to be of great usefulness at a center where students come for research. Not only is this branch of botanical study, as well as others emphasized, it is important to consider that mycological study here contributes to, and is supplemented by, other fields of research in related departments, as well as in the work of the Experiment Station, and in that of the newly organized College of Forestry.

Specimens may be sent to either of the following addresses:

PROFESSOR GEO. F. ATKINSON,
Botanical Department,
Cornell University, Ithaca, N. Y.

or,

CORNELL MYCOLOGICAL CLUB, Ithaca, N. Y.

Persons desiring to join the Club should send name with the annual fee enclosed, to either of the above addresses. The fee should *not be sent in postage stamps*, but preferably in a postal note when in so small a sum, unless the "quarter" is enclosed in a mailing card for the purpose. The cost of sending will be reduced where several from the same locality choose to send names and fees in a single letter. The exact address should also be given for each person, with the street number where necessary.

Those wishing to take up the study of the fungi would find it profitable to attend some school where suitable opportunities are offered for beginners. A course in mycology* (devoted especially to the mushrooms) will be given during the summer of 1899 in the Botanical Department of Cornell University.

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* Besides the course in mycology, courses in general morphology and physiology of plants, as well as a course in ecology are offered in the summer school especially for teachers. The catalog of the summer school can be obtained by addressing, The Registrar, Cornell University, Ithaca, N.Y. A full year's course in mycology is given during the regular annual session of the University as described in the annual Register.

NOTE.—The author was asissted in making some of the photographs illustrating this bulletin, by Mr. H. Hasselbring, and Mr. B. F. White.

Bulletin 169. **May, 1899.**
Cornell University Agricultural Experiment Station,
ITHACA, N. Y.
DAIRY DIVISION.

Studies in Milk Secretion

DRAWN FROM THE

RECORDS OF THE UNIVERSITY HERD

1891-1898.

By HENRY H. WING and LEROY ANDERSON.

PUBLISHED BY THE UNIVERSITY.
ITHACA, N. Y.
1899.

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STUDIES IN MILK SECRETION.

The University herd has consisted during the past several years of about twenty cows, the most of which have been grade Jerseys and grade Holsteins. In building up the herd the aim has been to form one that would furnish an object lesson to those farmers who desire to improve their herds but do not feel able to purchase thoroughbred stock entirely. Accordingly the herd has been developed from the ordinary stock of the neighborhood by the use of thoroughbred bulls and a rigid selection of the best heifers. This course of breeding was established by Professor Roberts in 1875 and has been continued ever since In 1874 the average yield of milk per cow was a little more than 3000 pounds. The descendants of these same cows, as will be seen in the following pages, have produced an average of over 7,500 pounds during the year 1897–'98. This increase of two and one-half times is the result of judicious selection of sire and dam, together with careful feeding, and is a result which every farmer can obtain by following a similar course.

The general management of the herd is on the plan of a winter dairy, *i. e.*, the cows are bred, so far as possible, to calve during the early fall months. They are milked about ten months and most of them are dry during July and August. In the summer they are at pasture which is supplemented with corn or other green forage crops whenever the pasture becomes dry or scanty. In the winter they are stabled at night and during the day run in a covered yard which is well bedded and where they have access to water, none being supplied in the stable. The frontispiece shows the cows in the covered yard mentioned.

Since the introduction of the Babcock test a careful record has been kept of the amount of butter-fat produced by the herd.

Each cow's milk is weighed daily and once a week a sample of an equal amount of nights and mornings milk is taken from each cow. The fat in these samples of mixed milk is determined by the Babcock test and this percentage multiplied by the number of pounds of milk given during the week is taken to represent the number of pounds of fat produced during that week. Although this method does not give the actual amount of fat produced, still it gives a very close approximation thereto and is sufficiently accurate for practical purposes in estimating the producing power of any individual cow.

The records given in the following table (I) begin with September 1891 and continue until the fall of 1898 and are for all the cows which have been in the herd during that time. These records contain the cow's age, breed, date of calving, the number of the lactation period, the number ot weeks in the period, the total milk produced, the average per cent of fat and the total fat for the period. The breed of each cow is indicated by the initials following her name. J., designating Jersey, H., Holstein, T., Thoroughbred, G., Grade, and J.-H., Jersey-Holstein.

TABLE I.—PRODUCT OF MILK AND FAT.

Name of Cow.	Breed.	Age	Date of Calving.	Number of Lactation.	No. of Weeks in Lactation.	Total Pounds of Milk.	Average per cent Fat.	Total Pounds of Fat.
Aggie, 2nd.....	15/16 H.	2	Sept. 1892	1	27	3415.25	3.07	104.93
Beauty.......	G.J.	?	Jan. 1892	5?	35	6192.00	4.87	301.74
			Nov. 1892		39	6176.25	4.82	297.59
			Sept. 1893		41	6474.25	4.61	298.70
			Sept. 1894		41	6300.00	4.47	281.70
			Sept. 1895		24	4416.00	4.46	196.91
Belle..........	J.H.	2	Aug. 1897	1	52	7098.75	4.44	314.91
Belva.........	7/8 H.	5	Oct. 1891	4	42	9921.25	3.07	304.72
		6	Sept. 1892	5	46	9720.50	3.21	312.05
		7	Oct. 1893	6	40	9203.25	3.04	279.41
		8	Sept. 1894	7	34	8313.75	3.23	268.43
Belva, 2nd.....	15/16 H.	2	Sept. 1895	1	44	6272.00	3.29	206.45
		3	Sept. 1896	2	42	8300.25	3.16	262.17
		4	Sept. 1897	3	48	8746.50	3.22	281.79
Bertha.........	G.J.	3	Sept. 1891	2	42	4371.50	5.02	219.47
		4	Oct. 1892	3	45	5990.75	4.94	295.95
		5	Sept. 1893	4	42	5920.50	4.94	292.28
		6	Sept. 1894	5	44	6250.00	4.83	301.62
		7	Aug. 1895	6	59	8595.75	4.84	415.96
Bertha, 2nd....	G.J.	2	Jan. 1897	1	39	5630.50	4.66	262.02
		3	Jan. 1898	2	52	8150.00	4.63	376.02
Carrie.........	G.H.	2	Oct. 1891	1	84	9363.75	3.79	354.97
Cherry........	G.J.	2	Sept. 1895	1	46	4085.50	5.44	222.46
		3	Sept. 1896	2	48	5442.25	5.37	292.40
		4	Oct. 1897	3	49	6299.50	5.33	335.87
Clara..........	G.J.	2	Oct. 1894	1	37	3547.00	5.28	187.31
		3	Sept. 1895	2	43	4405.50	5.08	223.67
		4	Sept. 1896	3	30	3893.00	4.99	194.08
Cora	G.J.	?	Jan. 1892	7?	38	5914.00	5.29	312.88
			Dec. 1892		34	5827.75	4.95	288.36
			Dec. 1893		17	3732.00	4.98	185.98
Daisy..........	G.J.	2	Sept. 1891	1	41	2203.00	5.91	130.13
		3	Sept. 1892	2	46	3433.00	5.60	192.32
		4	Sept. 1893	3	38	2669.5	5.63	150.21
		5	Sept. 1894	4	41	3698.25	5.56	205.50
		6	Sept. 1895	5	8	876.25	5.17	45.26

TABLE I.—*Continued.*

Name of Cow.	Breed.	Age	Date of Calving	Number of Lactation.	No. of Weeks in Lactation.	Total Pounds of Milk	Average per cent Fat.	Total Pounds of Fat.
Daisy 2nd.....	G.J.	2	Sep. 1896	1	45	3505.75	4.79	168.16
		3	Sep. 1897	2	24	2304.25	5.05	116.36
Dora..........	15/16 H.	2	Aug. 1893	1	45	9325.75	3.15	293.96
		3	Aug. 1894	2	43	9450.50	3.14	297.20
		4	Sep. 1895	3	53	9681.00	2.93	283.93
		5	Nov. 1896	4	47	11905.00	3.00	356.73
		6	Dec. 1897	5	43	10926.75	3.03	331.38
Emma.........	15/16 H.	2	Feb. 1893	1	52	8421.50	3.17	267.33
		3	May 1894	2	59	10828.50	3.36	364.
		4	Aug. 1895	3	42	9396.75	2.93	275.02
		5	Sep. 1896	4	42	10258.00	3.01	308.79
		6	Aug. 1897	5	46	9500.00	2.98	283.51
Freddie.......	¾ H.	6	Oct. 1891	5	41	10705.25	3.72	396.26
		7	Sept. 1892	6	42	9906.50	3.72	368.55
		8	Aug. 1893	7	45	11692.25	3.52	412.22
		9	Aug. 1894	8	38	10913.75	3.41	371.84
Garnet St. Lambert	T.J.	2	Oct. 1897*	1	52	5894.50	4.92	290.05
Garnet Valentine.........	T.J.	2	Aug. 1893	1	46	4811.75	5.13	247.01
		3	Aug. 1894	2	43	5544.25	4.52	250.81
		4	Aug. 1895	3	43	5807.00	4.51	261.86
		5	Aug. 1896	4	44	4390.50	4.34	190.63
Gazelle..	G.J.	4	Feb. 1892	2	35	4641.50	5.05	233.32
		5	Dec. 1892	3	38	5123.25	5.17	265.02
		6	Oct. 1893	4	39	5781.50	5.11	295.71
		7	Sep. 1894	5	39	4951.50	5.14	254.71
		8	Aug. 1895	6	18	2859.25	4.61	131.71
Gem Valentine.	T.J.	3	Mar. 1892	2	35	3258.25	5.78	188.56
		4	Jan. 1893	3	34	4536.50	5.64	255.86
		5	Nov. 1893	4	39	4732.75	5.61	265.43
		6	Oct. 1894	5	35	4063.50	5.58	226.83
		7	Sep. 1895	6	43	5144.00	5.42	278.78
		8	Sep. 1896	7	48	6103.75	5.50	335.46
		9	Oct. 1897	8	50	6458.75	5.24	338.82
Glista.........	T.H.	4	Sep. 1891	3	49	6935.50	3.49	241.80
		5	Oct. 1892	4	23	3048.50	3.56	108.49
Glista 2nd.....	T.H.	2	Sep. 1891	1	53	6082.00	3.12	189.58
		3	Nov. 1892	2	16	1451.75	2.89	42.00

TABLE I.—*Continued.*

Name of Cow.	Breed.	Age	Date of Calving.	Number of Lactation	No of Weeks in Lactation.	Total Pounds of Milk.	Average per cent Fat.	Total Pounds of Fat.
Glista 3rd.....	T.H.	2	Sep. 1893	1	45	8049.25	3.52	283.45
		3	Sep. 1894	2	40	5783.50	3.59	207.78
		4	Sep. 1894	3	34	5868.25	3.29	193.15
Glista 4th.....	T.H.	2	Oct. 1894	1	40	5850.75	3.78	220.06
		3	Sep. 1895	2	44	6819.75	3.21	219.26
		4	Sep. 1896	3	47	9854.50	3.30	325.28
		5	Sep. 1897	4	43	9076.75	3.23	292.75
Glista Netherland	T.H.	3	Oct. 1895	1	73	14780.00	3.21	474.64
		5	May 1897	2	61	12356.75	3.07	379.36
Jennie	G.J.	4	Mar. 1892	2	62	7118.00	5.12	364.37
		5	Aug. 1893	3	66	8440.75	5.40	456.06
Jennie 2nd.....	J.-H.	2	Nov. 1895	1	41	4746.75	4.28	203.01
		3	Nov. 1896	2	38	5759.50	4.26	245.44
		4	Oct. 1897	3	56	7161.50	4.32	309.51
Julia	⅞H.	2	Sep. 1893	1	45	7144.50	3.29	234.86
		3	Oct. 1894	2	40	7599.50	3.45	262.51
		4	Oct. 1895	3	40	9855.75	3.31	326.56
		5	Sep. 1896	4	47	7715.00	2.91	224.28
		6	Oct. 1897	5	40	8507.50	3.30	280.87
Mabel.........	15/16H.	2	Sep. 1892	1	46	7347.00	3.24	238.38
		3	July 1893	2	62	6938.50	3.45	239.30
		4	Jan. 1895	3	35	7984.25	3.85	307.86
Mabel 2nd	J.-H.	2	Oct. 1896	1	49	7301.75	4.05	296.14
		3	Nov. 1897	2	35	6162.00	3.89	239.87
May 2nd.......	⅞H.	2	Sep. 1894	1	41	5815.25	3.17	184.35
		3	Sep. 1895	2	47	6249.00	2.92	182.68
		4	Sep. 1896	3	41	7686.00	3.32	254.98
		5	Sep. 1897	4	58	10273.75	3.11	319.28
Mollie	15/16H.	2	Sep. 1891	1	41	7203.50	3.31	238.49
		3	Sep. 1892	2	42	8132.75	3.50	284.41
		4	Sep. 1893	3	51	10204.50	3.51	358.36
		5	Oct. 1894	4	40	9948.50	3.55	352.85
		6	Sep. 1895	5	52	11115.00	3.19	354.76

TABLE I.—*Continued.*

Name of Cow.	Breed.	Age	Date of Calving.	Number of Lactation	No. of Weeks in Lactation.	Total Pounds of Milk.	Average per cent Fat.	Total Pounds of Fat.
Mollie.	15/16H.	7	Oct. 1896	6	40	10991.00	3.30	363.21
		8	Sep. 1897	7	45	11023.50	3.14	345.75
Nora..........	⅞H.	2	Sep. 1894	1	40	6093.50	3.41	207.58
		3	Aug. 1895	2	38	6994.25	3.40	237.46
Pearl..........	⅞H.	3	Sep. 1891	2	44	9105.25	3.36	305.76
		4	Sep. 1892	3	41	8963.25	3.33	298.86
		5	Sep. 1893	4	43	10142.00	3.53	357.79
		6	Aug. 1894	5	75	13619.50	3.29	448.47
		8	May 1896	6	40	10764.75	3.26	351.32
Pet..........	⅞H.	7	Mar. 1892	4	41	9647.50	3.34	322.55
		8	Apr. 1893	5	47	10208.25	3.38	344.80
		9	Apr. 1894	6	43	11482.50	3.58	410.64
		10	June 1895	7	15	4595.00	3.14	144.51
Pet 2nd.......	15/16H.	2	May 1896	1	37	4360.50	3.31	154.50
		3	Mar. 1897	2	54	6416.00	3.32	213.25
Puss	⅞H.	7	Dec. 1891	6	50	11835.25	2.96	349.94
		8	Feb. 1893	7	64	11951.25	2.85	340.22
Roxy	⅞H.	2	Nov. 1892	1	42	6374.25	3.66	233.53
		3	Oct. 1893	2	45	3619.00	3.37	121.78
		5	Jan. 1895	3	17	3557.50	3.93	139.74
Ruby..........	¾H.	3	Sep. 1891	2	53	9174.50	3.49	320.23
		4	Nov. 1892	3	57	9968.25	3.44	342.84
		5	Feb. 1894	4	40	11086.00	3.49	386.50
		6	Jan. 1895	5	38	10781.50	3.42	369.01
		7	Dec. 1895	6	48	13574.00	3.17	430.15
		8	Dec. 1896	7	64	16089.50	3.24	521.32
Ruth..........	31/32H.	2	Jan. 1897	1	39	6464.00	3.17	205.02
		3	Nov. 1897	2	38	5922.75	3.06	181.16
Sadie..........	15/16H.	2	Mar. 1894	1	42	6441.75	3.51	226.12
		3	Mar. 1895	2	49	8305.50	3.49	289.46
		4	May 1896	3	50	8650.75	3.26	282.07
		5	June 1897	4	30	5006.75	3.45	172.97
Shadow........	G.	?	Oct. 1891	?	49	8590.00	4.44	380.97
Sue.	G.	?	Nov. 1891	?	53	10625.25	4.10	435.38
Valerie St. Lambert.....	T.J.	2	Sep. 1897	1	52	5679.50	5.04	286.16

A survey of the above table will call to mind some of the principles upon which are based the selection of animals for the herd. Several instances of short periods of lactation will be noted and these are almost invariably the last lactations of those cows which were no longer considered profitable and were therefore sent to the shambles. This is notably the case with some whose records appear for only a year or two, e. g. Daisy 2nd, Glista, and Glista 2nd. These were kept in the hope that they would show enough improvement over their first year's record to warrant their continuance in the herd. But as such improvement did not occur, they were sold to the butcher.

Attention is also called to the records of several heifers as compared to the performance of their dams. The cow Daisy was kept in the herd much longer than profitable in the anticipation that she might develop into something good. She did not do nearly so well as her dam, Cora, and was improved upon by her daughter, Daisy 2nd. The latter, however, made a poor record as a two-year-old, which, together with her poor promise the following year, made her keeping unprofitable. Three other heifers, Bertha 2d, Garnet St. Lambert, and Valerie St. Lambert, all sired by the same bull as Daisy 2nd (Cornell's Exile, 30778 A. J. C. C.) have records which bear a different relation to those of their dams than does that of Daisy 2nd. Bertha 2nd as a two-year-old, exceeded her dam Bertha, in both milk and butter production when three years old. And her three-year-old record is better than any record of her dam until the latter reached the age of seven years. Garnet St. Lambert as a two-year-old produced more milk and fat than her dam Garnet Valentine in any year of her life. The latter died of milk fever in September 1897. The dam of Valerie St. Lambert was Gem Valentine, and she gives promise, judging from her two-year-old performance, of being a more profitable cow than her dam.

Of the four heifers mentioned, all did better than their dams, but even this fact, in the case of Daisy 2nd, did not make her a profitable cow, because both dam and daughter were light producers. The dams of the other three were fairly good cows and as the daughters were improvements upon them, the latter were of still greater value. This illustration goes to show the advisability of selecting heifers from the best cows rather than depending too much upon the good qualities of the sire.

Three of the cows are the product of a Jersey-Holstein cross. Jennie, a grade Jersey, was the dam of Jennie 2nd by a thoroughbred Holstein-Friesian bull. A comparison of their four-year-old records shows the daughter to have produced more milk but less fat than the dam. In that year the former's average per cent of fat was .8 of one per cent less than that of the latter. Mabel 2nd is the result of breeding Mabel, a high-grade Holstein-Friesian to a thoroughbred Jersey bull, Cornell's Exile. As a two-year-old the daughter produced slightly less milk and more fat than the dam, while as a three-year-old she produced more milk and fat for the same number of weeks than her dam. Her per cent of fat was about three-fourths of one per cent higher than Mabel's for the first two years. Belle is also by Cornell's Exile and is out of Ruby, a three-fourths Holstein-Fresian cow. Ruby's record as a two-year-old does not appear, but in compari-

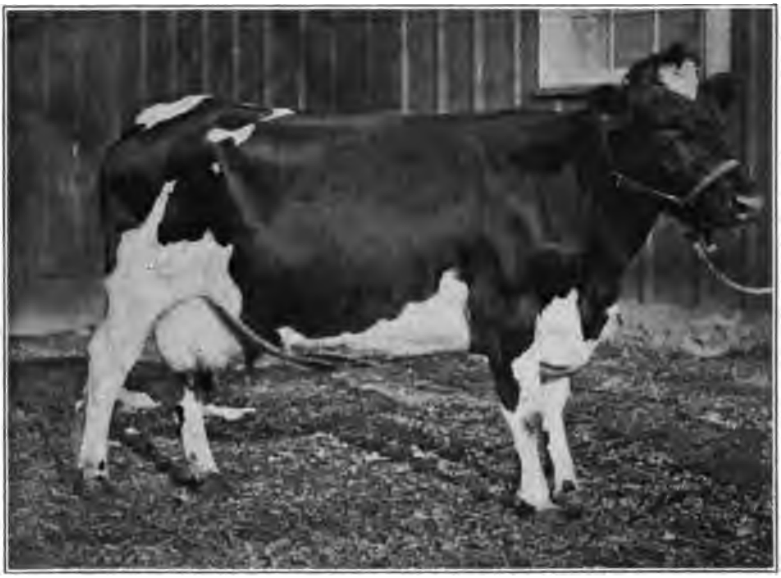
98.—*Ruby at two years of age.*

son to her three-year-old performance, Belle's production when two years old is over 2,000 pounds less in milk and about five pounds less in total butter fat. This great difference is occasioned by Belle averaging about one per cent higher in fat than her dam. Ruby produced 8,448 pounds of milk as a two-year-old and had she averaged the same per cent of fat as when three years old, Belle's record for butter fat at the same age would have exceeded hers by twenty pounds.

99.—*Kate daughter of Ruby at two years of age.*

The longest single period of lactation was that of Glista Netherland for 73 weeks. This was her first lactation and during this time she produced 14780 pounds of milk containing 474.64 pounds of butter-fat. A comparison of her record with that of Glista 4th will be of interest, since they are practically of the same age and are very closely related, both being by the same sire and Glista 4th's dam is Glista Netherland's grand dam. Glista 4th has had four calves; been in milk a total of 174 weeks and produced 31601.75 pounds of milk and 1057.35 pounds of fat. Glista Netherland during practically the same time has had two calves; been in milk 134 weeks; and produced 27136.75 pounds of milk and 854 pounds of fat.

The largest yield of milk for one lactation period was that of Ruby as an eight-year old, or 16089.50 pounds in 64 weeks. Her production of fat for this period was 531.32 pounds equivalent to 625 pounds of butter containing 85 per cent fat. As a two-year old she gave promise of being a good cow by producing in one year 8448 pounds of milk. Her picture is here reproduced as she appeared when two years old and also one taken in the fall of 1898 when ten years old. A picture of her daughter, Kate, now two years old, is also given to show the close resemblance between calf and dam at the same age. Kate dropped her first calf Sept. 16, 1898 and up to April 1st 1899 had produced 3684 pounds of milk. This is much less than her dam gave in the same length of time and it will be interesting to see if she ever resembles her as much in production as in appearance.



100.—*Ruby at ten years of age.*

AVERAGE PRODUCTION.

The average production of all the cows for each year is given in Table II, together with the highest and lowest records for that year. These records were selected according to the relative production of butter-fat and without regard to the yield of milk. Since most of the cows are fresh in the Fall, the "dairy year" is considered to run from September first to August thirty-first and the averages are for the production of the cows during that period.

TABLE II.—AVERAGE PRODUCT OF MILK AND FAT.

Year.		Number of cows.	Age.	Pounds of milk.	Per cent. fat.	Pounds of fat.
1891–'92..	Average........	19	4.0	7163.42	3.94	282.07
	Highest (Sue)...		5?	10625.25	4.10	435.38
	Lowest (Daisy)..		2	2203.00	5.91	130.13
1892–'93..	Average.......	17	4.6	6875.00	3.93	270.28
	Highest(Freddie)		7	9906.00	3.72	368.55
	Lowest (Carrie).		2	4122.50	4.08	168.30
1893–'94..	Average........	19	4.5	7563.32	3.86	291.92
	Highest (Pet)..		8	11782.25	3.55	418.03
	Lowest (Roxy)..		3	3619.00	3.37	121.78
1894–'95..	Average.........	22	4.8	7162.95	3.77	270.12
	Highest (Ruby).		6	11816.00	3.40	402.27
	Lowest (May 2d).		2	5815.25	3.17	184.35
1895–'96..	Average........	19	4.2	7456.25	3.57	265.88
	Highest (Ruby).		7	13446.75	3.19	428.75
	Lowest (May 2d)		3	6249.00	2.92	182.68
1896–'97..	Average........	20	4.2	7495.43	3.62	271.66
	Highest (Ruby).		8	13416.00	3.23	432.83
	Lowest(Daisy2d)		2	3505.75	4.79	168.16
1897–'98..	Average........	19	4.7	7575.33	3.68	278.51
	Highest (Mollie).		8	11023.50	3.14	345.75
	Lowest (Pet 2d).		3	4682.75	3.29	154.11
	Average of all..	135	4.4	7331.60	3.76	275.69

From this table it is seen that the largest production of fat for any one year was 435.38 pounds. This was from 10,625.25 pounds of milk containing an average of 4.1 per cent fat. The largest yield of milk for one year was 13,446.75 pounds which contained an average of 3.19 per cent fat and a total of 428.75 pounds of fat. The smallest production of fat was in the year 1893–94 and was 121.78 pounds. This was from 3,619 pounds of milk containing an average of 3.37 per cent fat. The smallest yield of milk was 2,203 pounds in the year 1891–92. This contained an average of 5.91 per cent fat and a total of 130.13 pounds of fat. The annual average yield of milk varied from 6,875 pounds in 1892–93 to 7,575 pounds in 1897–98. The average production of fat varied from 265.88 pounds in 1895–96 to 291.92 pounds in 1893–94. The lowest average per cent of fat (3.57) was also in 1895–96, while the highest average (3.94) was in 1891–92. The average of all the cows for the seven years was 7,331.6 pounds of milk, 275.69 pounds of fat and 3.76 per cent fat. The average age for each year ranges from 4 years in 1891–92 to 4.8 in 1894–95. The average age for seven years is 4.4 years. It should be noticed that the lowest record for each year was by either a two or three year old, while the highest record was in each case by a full aged cow.

PRODUCTION AS INFLUENCED BY AGE.

With a view to determine the average gain in production as a cow increases in age, we have taken from the records that go to make up Table I, such records as there are beginning with two-year olds and continuing for two or more years. In order to make this comparison as just as possible, the first forty weeks in each period of lactation are taken to represent the cows production for that period. In only a comparatively few cases do the periods taken in this comparison fall short of forty weeks and these instances are noted in the table. While the shorter periods may work to the slight disadvantage of the cow concerned, still they do not materially affect the average of the whole, which is the most important part of the comparison. The milk records of Bertha, Gem Valentine, Pearl and Ruby as two-year olds were made during the year 1890–91 when the milk was not tested for fat and thus the amount of fat produced cannot be given. This comparison is shown in the following table (III) and along with the forty week records, is given the per cent of gain in milk and fat from one year to another.

TABLE III.—THE YIELD OF MILK AND FAT COMPARED ACCORDING TO AGE OF ANIMAL.

Name of cow.	Age.	Pounds of milk.	Per cent of increase or decrease.	Pounds of fat.	Per cent of increase or decrease.
Belva 2d	2	6034.75		195.49	
	3	8163.75	+35.2	256.74	+31.3
	4	8000.50	— 2.0	256.00	— 0.3
Bertha	2	4554.00			
	3	4225.25	— 7.2	212.66	
	4	5601.25	+32.6	274.41	+29.0
	5	5785.50	+ 3.3	286.15	+ 4.3
	6	6003.00	+ 3.8	289.19	+ 1.1
	7	6243 00	+ 4.0	296.22	+ 2.4
Bertha 2d	2	5630.50		262.20	
	3	6490.75	+15.3	293.80	+11.2
Cherry	2	3810.75		205.33	
	3	4741.00	+24.4	252.15	+22.8
	4	5638.25	+18.9	300.35	+15.1
Clara	2 c	3547.00		187.31	
	3	4221.25	+19.0	212.53	+13.5
Daisy	2	2149.00		127.13	
	3	3216.00	+49.2	178.81	+40.7
	4 d	2669.50	—17.0	150.21	—16.0
	5	3657.00	+37.0	203.11	+35.2
Dora	2	8758.50		271.52	
	3	9192.00	+ 4.9	287.95	+ 6.1
	4	8514.75	— 7.3	248.57	—13.7
	5	11241.00	+32.0	335.84	+35.1
	6	10545.75	— 6.2	318.42	— 5.2
Emma	2	7355.75		233.33	
	3	8584.75	+16.7	282.15	+20.9
	4	9303.00	+ 8.4	271.59	— 3.7
	5	10061.75	+ 8.2	301.98	+11.2
	6	8767.00	—12.8	259.15	—12.7
Garnet Valentine	2	4455.75		228.06	
	3	5395.00	+21.1	243.97	+ 7.0
	4	5626.00	+ 4.3	253.96	+ 4.1
	5	4306.50	—23.5	186.84	—26.4
Gem Valentine	2	5177.25			
	3 b	3258.25	—37.1	188.56	

b. 35 weeks. c. 37 weeks. d. 38 weeks.

TABLE III.—*Continued.*

Name of cow.	Age.	Pounds of milk.	Per cent of increase or decrease.	Pounds of fat.	Per cent of increase or decrease.
Gem Valentine......	4 a	4536.50	+39.2	255.86	+35.7
	5 e	4732.75	+ 4.3	265.43	+ 3.7
	6 b	4063.50	—14.1	226.83	—14.5
	7	4981.00	+22.6	269.31	+18.7
	8	5585.25	+12.1	306.27	+13.7
	9	5710.50	+ 2.2	299.17	— 2.3
Glista 3rd............	2	7666.00		265.61	
	3	5783.50	—24.6	207.78	—21.8
	4 a	5868.25	+ 1.5	193.15	— 7.0
Glista 4th............	2	5850.75		220.06	
	3	6539.75	+11.8	208.36	— 5.3
	4	8926.75	+36.5	291.38	+39.8
	5	8869.75	— 0.6	284.78	— 2.3
Jennie 2d............	2	4708.25		201.20	
	3 d	5759.50	+22.3	245.44	+22.0
	4	6075.25	+ 5.5	260.39	+ 6.1
Julia	2	6910.25		225.51	
	3	7599.50	+10.0	262 51	+16.4
	4	9855.75	+29.7	326.56	+24.4
	5	7237.50	—26.6	207.18	—36.6
	6	8507.50	+17.5	280 87	+35.6
Mabel	2	6781.75		218.54	
	3	5082.50	—25.1	173.40	—20.7
	4 b	7984.25	+57.1	307.86	+77.5
Mabel 2d	2	6397.00		257.08	
	3 b	6162.00	— 3.7	239.87	— 6.7
May 2d............	2	5630.50		180.88	
	3	5785.50	+ 2.8	168.00	— 7.1
	4	7640.25	+32.1	253.17	+50.7
	5	7838.00	+ 2.6	246.61	— 2.6
Mollie	2	7068.00		233.14	
	3	7828.00	+10.8	271.75	+12.3
	4	9145.25	+16.8	317.48	+16.8
	5	9948.50	+ 8.8	352.85	+11.1
	6	9732.00	— 2.2	308.78	—12.5
	7	10991.00	+12.9	363.21	+17.6
	8	10302.25	— 6.3	321.34	—11.5
Nora	2	6093.50		207.58	
	3 d	6994.25	+14.8	237.46	+14.9

a. 34 weeks. b. 35 weeks. c. 37 weeks. d. 38 weeks. e. 39 weeks.

TABLE III.—*Continued.*

Name of cow.	Age.	Pounds of milk.	Per cent of increase or decrease.	Pounds of fat.	Per cent of increase or decrease.
Pearl	2	6816.25			
	3	8666.00	+27.1	289.32	
	4	8963.25	+ 3.4	298.86	+ 3.3
	5	9952.75	+11.0	350.29	+17.2
	6	9041.50	— 9.2	300.95	—14.1
	7	10764.75	+19.1	351.32	+16.7
Pet 2d	2 c	4360.50		154.50	
	3	5332.75	+22.3	173.56	+12.3
Roxy	2	6317.25		230.96	
	3	3475.50	—45.0	116.12	—49.7
Ruby	2	7235.00			
	3	7442.00	+ 2.9	252	
	4	8249.50	+10.9	284.18	+12.8
	5	11086.00	+34.4	386.50	+36.0
	6 d	10781.50	— 2.7	369.01	— 4.5
	7	12740.00	+18.2	401.41	+ 8.8
	8	12576.50	— 1.3	404.20	— .07
Ruth	2 e	6464.00		205.02	
	3	5922.75	— 8.3	181.16	—11.6
Sadie	2	6352.50		222.37	
	3	7480.75	+17.8	257.97	+16.0
	4	7700.75	+ 2.9	249.95	— 3.1

c. 37 weeks. d. 38 weeks. e. 39 weeks.

AVERAGE OF RECORDS SHOWN IN TABLE III.

	No. of cow	Pounds of milk.	Per cent of increase.	Pounds of fat.	Per cent of increase.	Average per cent of fat.
Two-year olds	25	5844.99		*215.85		3.71
Three " "	25	6133.69	5.0	227.76	5.5	3.71
Four " "	18	7238.83	18.0	266.33	16.9	3.68
Full-aged cows	29	8346.66	15.3	302.52	13.6	3.62
Five-year olds	12	7893.08		283.96		3.60
Six " "	8	8430.22		294.15		3.49
Seven " "	5	9143.95		336.29		3.68
Eight and nine-year olds	4	8543.63		332.75		3.89
Average of all	97	6925.97		255.85		3.67

* Twenty-one two-year olds.

In this comparison there are 97 records of milk and 93 of fat production, 25 of the milk and 21 of the fat records being of two-year olds. Of the remainder the same number of animals are represented in both milk and fat, and of these, 25 are three year-olds, 18 four-year olds and 29 full aged cows. The average yield of all the cows was 6926 pounds of milk and 255.85 pounds of fat with an average of 3.67 per cent fat. The average increase in milk was five per cent from two to three year olds, 18 per cent from three to four year olds, and 15.3 per cent from four-year olds to full aged cows. The average increase in production of fat was 5.5 per cent from two and three year olds, 17 per cent from three to four year olds, and 13.6 per cent from four-year olds to full aged cows.

It will be noticed that the greatest increase in both milk and fat is from the ages of three to four while the smallest increase is from the ages of two to three. This is quite contrary to what was found in the case of seven day tests of thorough bred Holstein-Friesian cows, the records of which were published in Bulletin No. 152 of this Station. The gains of the older cows over the younger were so different in the two cases that the per cent increase in each is given in tabular form below for ready comparison.

PER CENT INCREASE.

	Milk.		Fat.	
	University Herd 40 Weeks.	Seven day test. Bul. 152.	University Herd 40 Weeks.	Seven day test. Bul. 152.
From two to three year olds	4.9	28.5	5.5	32.7
" three to four "	18.0	12.6	16.9	18.2
" four to five "	15.3	7.5	13.6	7.7

Were it a question as to which gives the more accurate estimate of the producing power of older cows over younger, the choice would undoubtedly fall to the records here given of the University herd. The latter is kept under conditions such as are found in all well conducted dairies and the records cover nearly, if not quite, the average yearly milking period of the ordinary cow. On the other hand the cows which are entered for the seven day tests are the pick of the herd; they are fed to the highest limit for a short period and thus forced to their utmost production for that time. Moreover the records are for too short a time to furnish an accurate estimate of the relative production of cows of different ages. Forty week records must, in the nature of the case, give us a surer basis of comparison than those which run for seven days only.

VARIATION IN YIELD OF MILK AND ITS FAT CONTENT AS LACTATION ADVANCES.

A point often discussed concerns the average rate of decrease in yield of milk as the period of lactation advances and also the average increase, if such there be, in the per cent of fat during the same time. As an indication of what this decrease in milk and increase in per cent of fat may be, a careful study was made of the individual records of all the cows in the herd. This study was conducted in the following manner: Beginning with the third week after calving the weekly records of each cow were divided into periods of four weeks each. The average daily yield of milk and the average per cent of fat were then determined for each of these periods. Considering the averages for the first period of four weeks in each lactation as 100, the average for each succeeding period was calculated to the same basis. The first two weeks after calving were thrown out of the calculation because so many abnormal conditions affect the flow of milk at that time. The records were worked out in this manner for each individual cow in each year, and from these were obtained the averages for seven years which appear below in Table IV. In this table also are given the yearly records of six individual cows representing various degrees of fluctuation in yield of milk and in per cent of fat. An explanation of the figures may be of value. In 1893–94, Dora (II.) had a daily average of 31 pounds of milk during the first four weeks of her lactation. If we represent this average of 31 as 100, then on the same basis her daily average for the next four weeks of 28.25

pounds, a decrease of nine per cent, would be represented by 91. In like manner her daily average of 31 pounds during the third period would be represented by 100. And so on through the whole period of lactation we reckon the average daily yield of each four weeks according to the ratio it bears to the yield in the first four weeks when considered as 100. The relative increase or decrease in per cent of fat was determined in the same manner, and is given in the table along with the variation in milk yield.

Following this table are three plates showing lines platted according to the figures given in the table. These lines show very plainly the variation in milk and per cent of fat from month to month. The record which each set of lines is intended to display is indicated by the Roman numeral which corresponds to the same number in table IV. Passing from left to right in these plates, each perpendicular line represents four weeks advance in the lactation period, and each space between the horizontal lines represents two pounds of milk or .2 of 1 per cent of fat. Keeping these points in mind, the reader, beginning at 100, will easily trace each record for milk and per cent. of fat as given in table IV.

TABLE IV.—RATIO OF VARIATION IN YIELD OF MILK AND PER CENT OF FAT, COUNTING THE DAILY AVERAGE FOR THE FIRST FOUR WEEKS AS 100.

Number of periods of four weeks each after calving.	I. Average for 135 cows.		II. Dora, 1893-94.		III. Mollie, 1895 96		IV. Belva 2d, 1896-97.		V. Daisy, 1892-93.		VI. Pet, 1893-94.		VII. Cherry, 1896 97.	
	Milk.	Per ct. fat.	Milk.	Per ct. fat.	Milk.	Per ct. fat.	Milk.	Per ct. fat.	Milk.	Per ct. fat.	Milk.	Per ct. fat.	Milk.	Per ct. fat.
1st actual....			31.00	3.16	35.25	3.55	29.00	3.20	15.00	5.10	40.75	2.72	21.75	4.80
1st relative..	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2d...........	96	96	91	95	97	83	105	93	80	100	110	113	88	109
3d	93	96	100	97	100	87	104	86	84	102	102	112	80	110
4th..........	89	97	109	90	103	89	108	94	79	110	99	131	70	116
5th..........	85	98	106	94	100	87	107	95	80	100	100	112	66	121
6th....... ...	81	98	97	94	100	90	109	100	79	110	68	131	70	116
7th	76	102	103	100	98	89	107	95	68	125	63	132	70	112
8th..........	71	103	105	99	97	90	108	108	63	119	63	144	81	114
9th..........	67	104	98	111	98	94	91	105	67	118	67	140	76	115
10th..........	62	104	100	108	84	91	46	118	57	115	58	150	68	111
11th..........	55	106	57	129	53	96			39	122	36	153	53	121

The average of all (I) includes 135 yearly records and such a large number must give a fair representation of the average decrease in yield of milk and increase in per cent of fat as the period of lactation advances. This average shows a gradual and fairly regular decrease in milk flow from the time of calving until the cow is dry. The decrease from one period of four weeks to the next varies from 3.1 to 11.3 per cent, while the average decrease is 5.3 per cent. This calculation also shows a decrease in the per cent of fat from the first month to the second and then a gradual rise to the end of the lactation period. The variation from one period of four weeks to the next is from minus 4 per cent to plus 4.1 per cent, while the average increase is slightly more than one-half of one per cent. The average per cent of fat during the eleventh month is only six per cent greater than during the first month. At no time during the milking period does the increase in per cent of fat compensate for the loss in yield of milk, in the production of total butter fat. This may be the case for a time with some individual cows but as a rule it does not occur so far as our records show. In other words a cow may generally be depended upon to give a larger yield of butter fat

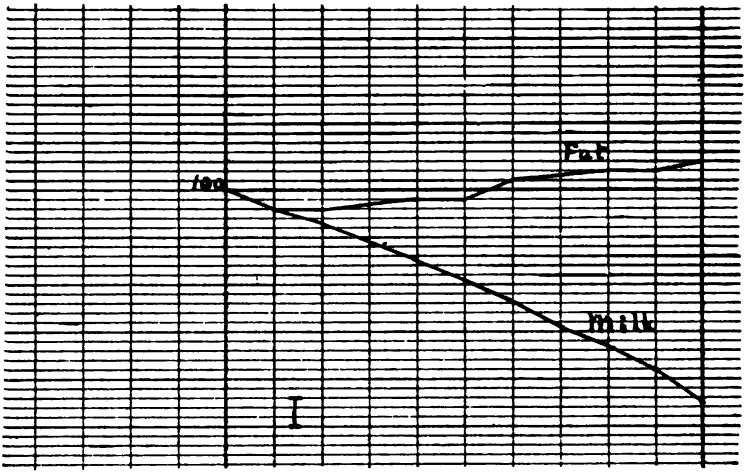


Diagram showing average variation in yield of milk and fat as lactation progresses.

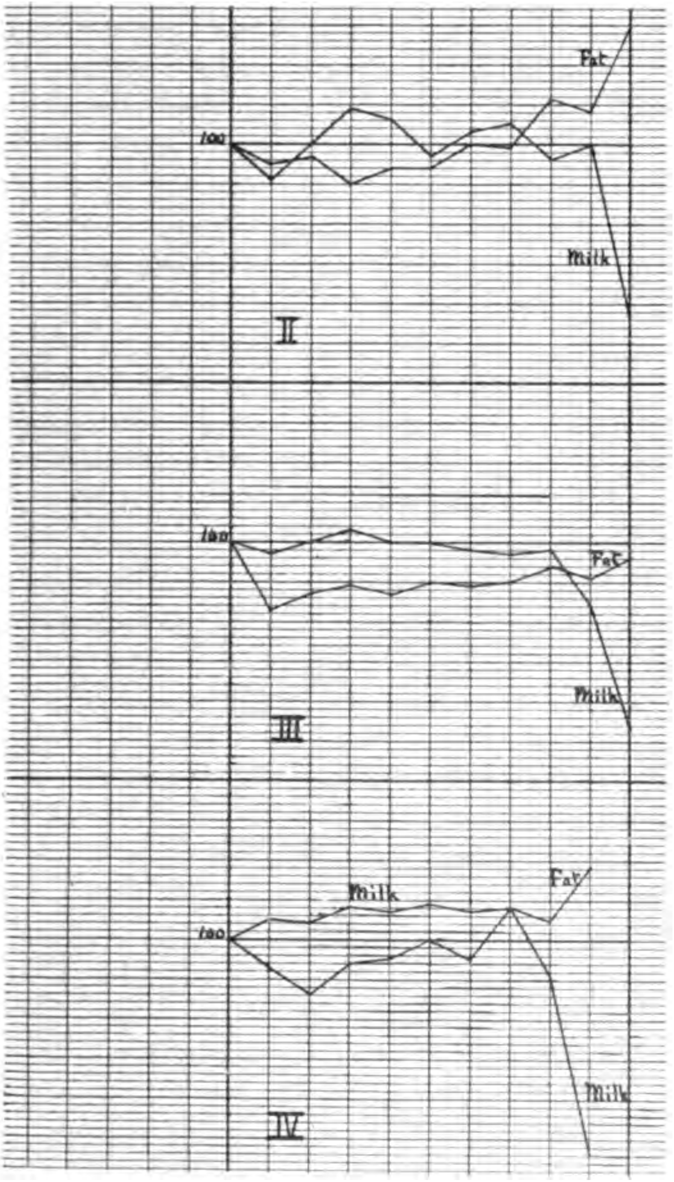


Diagram showing individual variations in milk and fat as lactation progresses.

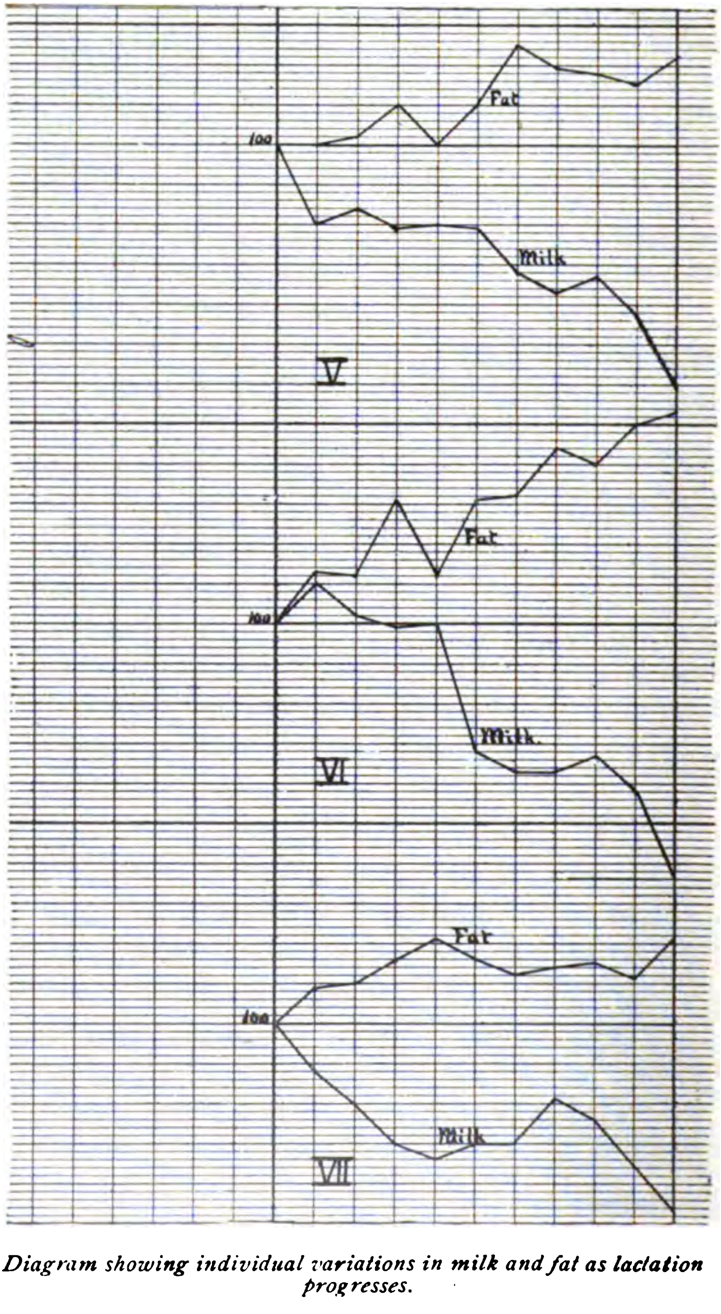


Diagram showing individual variations in milk and fat as lactation progresses.

during the first weeks of a milking period than at any subsequent time during the same lactation.

The record given of Dora (II), August, 1893 to July, 1894, is of her production as a two-year old. During this year she displayed a remarkable "holding out" power. In the second month she fell off in the daily average nine per cent, but for the next ten months she fell below her first average only twice and then no more than three per cent. At the end of the tenth period she declined so rapidly in milk that she was completely dry before the close of the eleventh. In per cent of fat she showed a variation which is found by these studies to be quite common, namely, a decrease for the second or third four weeks, and then a gradual rise to the close of the milking period. She dropped her second calf August 30, 1894, three days more than a year from her first calving. She "held out" in milk as a two-year old better than during any succeeding year.

Mollie (III) September, 1895 to September, 1896, displayed almost as continuous a milk flow as Dora in 1893–94. Beginning the first four weeks with a daily average of 35.25 pounds, she did not decrease more than three per cent until the tenth period, when she fell off 16 per cent and then declined rapidly until dry in the thirteenth period. In per cent of fat she was higher during the first month than at any other period except at the last end of lactation. This was her fifth lactation and her sixth calf was dropped 13½ months after the fifth.

Belva 2nd (IV.) September 1896 to July 1897, likewise showed much power in "holding out" in her milk flow. At the end of the eighth four weeks, her daily average had not fallen below that of the first period, but then she declined rapidly and went dry at the end of the tenth four weeks. In per cent of fat she shows much the same characteristics as were noted in Dora (II). This was her record as a three-year-old and her third calf was born a little less than a year after the second.

Daisy (V.) September 1892 to July 1893, showed a decrease in milk flow which is rather more than the average and at the same time an increase in per cent of fat which is much greater than the average. During the seventh month the per cent of fat rose 25 per cent above the average for the first four weeks and this without any apparent cause so far as the records show. After this there was a decrease and again a rise to 22 per cent above the first month at the end of lactation. This was her second year in milk and her third calf was dropped one year after the second.

Pet (VI.) April 1893 to March 1894, showed the greatest increase in per cent of fat of any of the cows in the herd, it having increased gradually until at the last of the milking period it was over 50 per cent greater than at the beginning. At the same time the decrease in flow of milk was very great after the close of the fifth month. During the following month it fell off 32 per cent. This great decrease was occasioned by her being taken to the New York State Fair. On September 13, 1893 her milk yield at the home barn was 35.75 pounds. The next day she was at the Fair grounds and gave only 26.5 pounds. She did not again recover her former yield. When the milk flow thus fell 32 per cent the per cent of fat rose 31 per cent, but it should be noted that the per cent of fat reached as equally high a point during the fourth month. The average per cent of fat for the first four weeks of this lactation was lower then for a similar period of any other year. This low average may have been abnormal with her and thus show an unusual increase as the period of lactation advanced. It was her fourth lactation and her fifth calf was dropped about one year after the fourth.

Cherry (VII.) September 1896 to August 1897, represents another instance where the per cent of fat was lower during the first few weeks than at any subsequent time during the same lactation period. And like Pet mentioned above, the per cent of fat at the beginning of this milking period was lower than for a similar time during any of her other lactations. This may account for the more than average increase in the per cent of fat as the lactation advanced. She dropped her second calf Sept. 18, 1896, and her third calf Oct. 28, 1897.

EFFECT OF THE CHANGE FROM BARN TO PASTURE.

When cows are turned from dry stall feed into the fresh pasture of early summer they invariably increase in yield of milk. This is a fact known to all dairymen, but the effect of the same change on the quality of milk is not so well understood. Probably it is the general belief that the early summer pasture tends to produce a milk less rich in fat than the barn feed. The records of the University herd throw some light on the effect of this change in feed both on the quantity and quality of the milk. In considering these records, however, it should be borne in mind that nearly all the cows are fresh in milk in the early fall and are therefore so near to the end of the lactation period that most of them are dried off within six weeks to two months after they are turned to pasture. Under these conditions it is not to be expected they would show so much variation on a radical change of food as though they were fresh just before the change. Up to the time of going to pasture the cows receive an abundant ration of corn silage, mixed or clover hay, grain and roots, usually mangel wurtzels. On going to pasture, this ration is discontinued entirely except for some grain and what little hay the cows will eat at milking time. About one third or one fourth as much grain is given as when on full stall feed except to such of the cows as are fresh in the spring which receive about as much as they will eat. If the pasture continues good the grain is taken entirely away from all except the fresh cows.

To compare the quantity of milk given under the two conditions above named, the daily average yield for each cow was determined for four separate periods, viz: the last three weeks before going to pasture; the first week at pasture; the first two weeks at pasture; and the three weeks following the first two at pasture. From these averages was found the daily increase or decrease per head for each of the three periods at pasture as compared with the period on barn feed. The per cent of fat for each cow was averaged for the same periods and the increase or decrease determined.

In the following table (V) are given the individual records of the variation in milk and per cent of fat for one year (1898) in order to show the method of comparison and how some cows increase while others decrease under seemingly the same conditions. There are also given the averages for all the cows for each year and for the six years during which this study is carried.

Some interesting data on this same point has been published by the Vermont Agricultural Experiment Station * and their results are appended in the table, to be compared with the results found at this Station. The daily averages for the Vermont herds were compiled for two periods, viz: the last twenty days before going to pasture; and the twenty days following the first ten at pasture.

TABLE V.—EFFECT OF THE CHANGE FROM BARN TO PASTURE ON THE MILK YIELD OF INDIVIDUAL COWS FOR 1898.

Name of cow.	Date of calving.	Average for last 21 days on barn feed.	Average for first 7 days on pasture	Increase or decrease.	Average for first 14 days on pasture	Increase or decrease.	Average for 21 days after first 14 days on pasture	Increase or decrease.
Belle	Aug. '97	18.25	19.00	+ .75	19.50	+1.25	19.75	+1.50
Belva 2d	Sept. '97	25.75	25.00	— .75	25.25	— .50	25.50	— .25
Bertha 2d	Jan. '98	22.25	23.50	+1.25	22.75	+ .50	24.75	+2.50
Cherry	Oct. '97	18.75	19.75	+1.00	19.75	+1.00	19.00	+ .25
Dora	Dec. '97	39.25	43.00	+3.75	42.75	+3.50	41.50	+2.25
Emma	Aug. '97	20.75	19.50	—1.25	21.25	+ .50	20.50	— .25
Garnet St. Lambert	Oct. '97	15.50	17.50	+2.00	17.25	+1.75	14.00	—1.50
Gem Valentine	Oct. '97	17.75	18.50	+ .75	19.00	+1.25	18.75	+1.00
Glista 4th	Sept. '97	28.75	30.25	+1.50	30.75	+2.00	28.75	.00
Glista Netherland	May '97	21.75	24.25	+2.50	24.50	+2.75	20.00	—1.75
Jennie 2d	Oct. '97	17.00	15.75	—1.25	14.25	—2.75	15.50	—1.50
Julia	Oct. '97	28.00	27.50	— .50	27 50	— .50	23.75	—4.25
Mabel 2d	Nov. '97	22.75	24.75	+2.00	24.75	+2.00	23.50	+ .75
May 2d	Sept. '97	22.75	25.00	+2.25	25.00	+2.25	25.25	+2.50
Mollie	Sept. '97	30.75	32.50	+1.75	33.00	+2.25	31.50	+ .75
Ruth	Nov. '97	22.50	21.00	—1.50	20.75	—1.75	20.50	—2.00
Valerie St. Lambert	Sept. '97	13.00	15.00	+2.00	14.75	+1.75	18.00	+5.00
Avg. of herd				+ .96		+1.01		+ .29

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* Third, fourth, sixth and seventh Annual Reports.

VARIATION IN PER CENT OF FAT FOR SAME PERIODS.

Name of cow.	Average for last 21 days on barn feed.	Average for first 7 days on pasture	Increase or decrease.	Average for first 14 days on pasture	Increase or decrease.	Average for 21 days after first 14 days on pasture	Increase or decrease.
Belle	4.43	4.60	+.17	4.50	+.07	4.13	—.30
Belva 2d	3.28	3.40	+.12	3.18	—.10	3.33	+.05
Bertha 2d	4.72	4.20	—.52	4.32	—.40	4.37	—.35
Cherry	5.13	5.20	+.07	5.23	—.10	4.98	—.15
Dora	2.80	3.00	+.20	3.05	+.25	2.88	+.08
Emma	3.20	3.55	+.35	3.48	+.28	3.20	.00
Garnet St. Lambert	5.42	5.00	—.42	5.05	—.37	4.63	—.79
Gem Valentine	5.13	5.05	—.08	4.93	—.20	4.98	—.15
Glista 4th	3.47	3.20	—.27	3.38	—.09	3.35	—.12
Glista Netherland	3.18	3.50	+.32	3.48	+.30	3.13	—.05
Jennie 2d	4.33	4.60	+.27	4.45	+.12	4.75	+.42
Julia	3.40	3.65	+.25	3.23	—.17	3.50	+.10
Mabel 2d	3.97	4.20	+.23	4.23	+.26	3.90	—.07
May 2d	2.98	2.95	—.03	3.08	+.10	2.92	—.06
Mollie	3.23	3.15	—.08	3.05	—.18	3.17	—.06
Ruth	2.80	2.90	+.10	3.00	+.20	3.27	+.47
Valerie St. Lambert	5.47	4.80	—.67	4.95	—.52	5.47	.00
Average of herd			+.00		—.02		—.06

AVERAGE DAILY INCREASE OR DECREASE IN YIELD OF MILK AND PER CENT OF FAT AFTER COWS WERE TURNED TO PASTURE.

Year.	No. of Cows.	Milk.			Per cent of Fat.		
		For first 7 days.	For first 14 Days.	For 21 Days after First 14 Days.	For first 7 Days.	For first 14 Days.	For 21 Days after First 14 Days.
1892	20	— .46	+ .21	+ .26	+.16	+.24	+.03
1893	16	— .44	+1.42	+1.20	+.06	+.07	—.22
1894	18	+1.24	+1.46	— .85	+.07	——	—.17
1895	19	+ .83	+1.21	—1.90	+.07	—.06	—.01
1896	15	+ .50	+ .03	—1.67	+.46	+.47	+.17
1898	17	+ .96	+1.01	+ .29	.00	—.02	—.06
Av. of all	105	+ .43	+ .90	— .45	+.13	+.13	—.04

VERMONT AGRICULTURAL EXPERIMENT STATION.

Year.	No. of Cows.	When fresh in Milk.	Average for 20 days after 1st 10 days. Lbs. milk.	Average for 20 days after 1st 10 days. Per cent fat.
1889	10	Mostly Fall	+3.50	—.18
1890	4	Fall	+4.80	+.02
1890	6	Fall	+1.30	+.46
1890	81	Spring	+8.80	+.14
1893	14	———	+1.30	+.21
1894	21	———	+2.75	+.37
Av. of all	136		+3 75	+.17

The results with the University herd show that more milk was given on pasture than on stall feed during the first two weeks after the change. The effect of pasture was more strongly felt the second week than the first. But during the three following weeks the average daily yield of milk fell back to nearly one-half pound below that for the last three weeks in the barn. In the per cent of fat there was much the same general result, a slight increase during the first two weeks at pasture and then a falling balk to practically the same per cent as was found under barn conditions. There was more or less variation from year to year, some years showing a decrease where others showed an increase, but the majority show much the same result as is found in the average of all.

The Vermont herds show a much greater increase, especially in yield of milk than the University herd. The greatest increase was for the 81 cows whose daily average was 8.8 pounds greater on pasture than when in the barn. These cows were not owned by the station, and their barn feed was much less nutritious than the pasture ration. This condition together with the fact that they were fresh in the spring accounts for the great increase after the change. The six cows in the year 1890, which showed an average daily increase of 1.3 pounds, received a less nutritious ration in the barn than was supplied by the pasture. The barn ration of all the other cows consisted of a liberal allowance of grain, hay and silage, and was as nutritious as the pasture. However, when the cows were turned to pasture, this barn feed was continued liberally, the cows standing in the barn every night. Comparing these records with those of the University herd for a similar period we find no case where the average increase for the herd equals that for the Vermont herds. In only one year (1893) does it approximate thereto and then only for the two lowest averages found in Vermont. The food conditions of the University herd have been given above, where it will be noticed that the barn ration must be fully as nutritious as pasture. Thus far the conditions correspond with those of the Vermont Station. But on turning to pasture the latter kept up the rich barn food while we eliminated nearly all of it, and herein may lie the cause of difference in results. The great increase of the 81 cows is the natural sequence of a change of fresh milkers from poor, dry feed to abundant succulent food, and cannot be justly compared with our conditions.

As regards quality of milk the Vermont records also show a greater increase in per cent of fat than was found for similar periods at this Station. During practically the same period after going to pasture our cows show nearly the same per cent of fat as when in the barn, while the Vermont herds show an increase of .17 per cent. Whether the differences in food conditions would account for this it is difficult to say.

Summing up, then, the comparison of records of the two Stations, and throwing out of the consideration the 81 cows, we have three varieties of conditions. First, 105 University cows changing from a rich barn ration to pasture by day and night with most of the former ration discontinued. Second, 39 Vermont cows changing from a rich barn ration to pasture by day with as much of the former ration continued as they will eat during the night. Third, six Vermont cows changing from a relatively poor barn ration to pasture by day with the same continuation of the former ration as in the second case. As results we have for the first case, a decrease in quantity and quality of milk after fourteen days of pasture; for the second and third cases, an increase in the quantity and quality of milk after ten days of pasture. This summary takes for granted that the length of time in milk is practically the same for all the cows. In the University herd it is found that some spring cows show no more increase in milk on going to pasture than do some fall cows.

COST OF MILK PRODUCTION.

During the year beginning January 15, 1892, and ending January 14, 1893, an accurate record was kept of the amount of food consumed by each cow as well as the amount of milk produced. From this record there was calculated the cost of producing milk and butter fat by each individual cow and the average cost for the herd. Owing to the fluctuation in price of feeds the cost of production then and now would differ even though conditions were otherwise the same. However, this variation in cost would occur between shorter periods owing to the same cause, and thus it does not seem out of place to publish in these pages the results of the experiment of 1892. Another reason for presenting them here is that the Bulletin in which they were originally published (No. 52) is out of print and so not accessible to the public. Accordingly we reprint here the more salient points and observations contained in that Bulletin.

In conducting this experiment it was the aim to feed a ration that would be eaten up fairly clean by all the cows. The foods used during the winter were hay, silage, roots, wheat bran, cotton-seed meal and corn meal. Only very slight variations were made from this list of foods. In the summer the cows had pasture of good quality and a grain ration, for the most of the time, of wheat bran and cotton-seed meal, supplemented with soiling crops when the pastures became dry.

The hay used was clover hay of a fair quality grown upon a wheat stubble and having a considerable proportion of volunteer wheat mixed with it, which was not readily eaten by the cows. The silage was made from Pride of the North corn grown in hills carrying a fair crop of ears. It was well preserved and of good quality. The roots used were almost wholly mangel wurtzels of medium size and good quality. The grain ration in January, February, March and April, 1892, was made up of a mixture of 300 pounds of bran, 200 pounds of cotton-seed meal and 60 pounds of corn meal. The corn silage crop of 1892 had considerably more grain than that of 1891, consequently, in November and December, 1892, and the first half of January, 1893, the corn meal was left out of the grain ration and three parts of bran and two parts of cotton-seed meal were fed. During the time the cows were at pasture the grain ration was made up of three parts bran and one part cotton-seed meal. The daily winter ration was as follows:

For the larger cows.	*For the smaller cows.*
15 lbs. hay.	10 lbs. hay.
50–55 lbs. silage.	40–45 lbs. silage.
10 lbs. roots.	10 lbs. roots.
8 lbs. grain.	8 lbs. grain.

The only exceptions made to this were that Freddie and Puss, during January, February and March, 1892, had ten pounds of grain instead of eight. The summer grain ration was four pounds per cow except during the month of June when one-half of the cows received no grain whatever. The cows while dry were fed no grain at all, the remainder of the ration being unchanged. In the latter part of the summer, particularly in the months of August and October, the pastures became very short and were supplemented in August with second growth clover, cut and carried to the cows, and in October with corn stalks. These were in every case weighed and charged to the cows consuming them. In making up the cost of the food consumed the following scale of prices was used, based as far as possible upon the market prices in Ithaca:

Hay	$ 9.00 per ton
Silage	1.75 per ton
Roots	2.00 per ton
Wheat bran	18.00 per ton
Oats	.35 per bu.
Cotton-seed meal	25.00 per ton
Corn meal	20.00 per ton
Corn stalks	3.00 per ton
Grass, cut and carried to cows	1.75 per ton
Pasture, exclusive of grain and silage crops	.30 per w'k

In Table VI is given the cost of food consumed by each animal; the total number of pounds of milk and fat produced and the cost of a hundred pounds of milk and one pound of fat for each individual and the average for the whole. The average cost of food consumed was $45.25; the highest for any one cow

TABLE VI.—COST OF FOOD, MILK AND FAT.

Cow.	Cost of food consumed during the year.	Pounds of milk produced.	Cost of 100 pounds of milk.	Pounds of fat prodnced.	Cost of one pound of fat.
Beauty	$44.24	8,028.50	$ .55	391.62	$.115
Belva	47.65	9,739.75	.49	309.19	.155
Bertha	42.00	4,743.25	.89	233.63	.18
Carrie	49.07	6,008.50	.82	219.34	.225
Cora	38.74	6,214.50	.62	326.68	.12
Daisy	41.24	2,829.75	1.48	159.02	.26
Freddie	52.06	11,165.00	.47	417.97	.125
Gazelle	39.96	5,670.50	.70	285.10	.14
Gem Valentine	36.24	3,387.75	1.07	197.33	.185
Glista	46.51	6,323.50	.74	224 71	.21
Glista 2d	43.80	5,136.00	.85	160.79	.27
Jennie	43.66	5,785.75	.75	294.30	.15
May	44.34	5,458.50	.81	195.31	.225
Mollie	45.98	7,757.25	.59	260.34	.175
Pearl	47.44	9,003.25	.53	299 07	.16
Pet	43.12	9,776 50	.44	330.59	.13
Puss	47.87	10,417.00	.46	302.93	.16
Ruby	48.63	7,955.00	.61	282 35	.17
Shadow	53.38	8,655.50	.62	382 77	.14
Sue	49.08	10,754.00	.46	439.37	.11
Total	$905.01	144,809.75		5,712.41	
Average	45.25	7,240.50	$.625	285.62	$.158

was $53.38 for the cow Shadow; the lowest $36.24 for Gem Valentine. The average cost of 100 pounds of milk was almost exactly 62½ cents; the highest for any one cow being $1.48 for Daisy; the lowest 44 cents for Pet. If we consider milk to be worth $1.00 per hundred weight at the barn two of the cows produced milk at a loss, Daisy and Gem Valentine. The average cost of butter fat was 15.8 cents; the highest 27 cents for Glista 2d; the lowest 11 cents for Sue. If we should consider fat to be worth 30 cents per pound, which is a little more than an equivalent of 25 cents a pound for butter, we should have no cows that produced fat at a loss for food consumed.

GENERAL SUMMARY AND CONCLUSIONS.

A good grade herd can be bred up from a herd of ordinary cows by the use of first-class thoroughbred sires and a careful selection of the best heifers.

By breeding in this way the University herd has increased in milk production from an average of 3,000 pounds per cow in 1874 to an average of 7,575 pounds in 1898.

It pays to select heifers from the best cows as well as to use only well bred bulls. Milk such heifers at least one year and then retain only those which give promise of being profitable producers.

The greatest production for one lactation period was by Ruby in 64 weeks, 16089.5 pounds of milk, and 531.32 pounds of fat, equivalent to 625 pounds of butter containing 85 per cent fat.

The average production for seven years was 7330 pounds of milk, 275 pounds of fat and 3.76 per cent fat. The average for each year varied from 6,875 pounds of milk in 1892–3, and 266 pounds of fat in 1895–96 to 7,575 pounds of milk in 1897–8, and 292 pounds of fat in 1893-94.

The average gain in production of milk as the cows increased in age was 5 per cent from two to three-year-olds, 18 per cent from three to four-year-olds, and 15.3 per cent from four-year-olds to full aged cows.

The average gain in production of butter fat was 5.5 per cent from two to three-year-olds, 17 per cent from three to four-year-olds, and 13.6 from four-year-olds to full aged cows.

Beginning with the third week after calving and dividing the remainder of the lactation into periods of four weeks, and then considering the average daily yield of milk of all the cows for the first period as 100 there was a gradual decrease in milk flow to 55 during the eleventh period.

Calculating the average per cent of fat in like manner, there was a decrease to 96 in the second period and then a gradual increase to 106 during the eleventh period.

Speaking in other terms there was an average decrease in yield of milk as lactation advanced, of about five per cent from each period of four weeks to the next. In per cent of fat there was an average increase of about one-half of one per cent from month to month.

As a rule, a cow will produce more butter during the first few weeks of a lactation period than at any equal subsequent time during the same lactation.

The general effect of the change from barn to pasture was an increase in both milk flow and per cent of fat for the first two weeks, and for the next three weeks a slight decrease in milk and per cent of fat below the daily average for the last three weeks in the barn.

During the year 1892 twenty cows produced milk for 62½ cents per hundred weight and fat for about sixteen cents per pound for the food consumed.

In general, the cows consuming the most food produced both milk and fat at the lowest rate.

Bulletin 170. **May, 1899.**
Cornell University Agricultural Experiment Station,
ITHACA, N. Y.
ENTOMOLOGICAL DIVISION.

EMERGENCY REPORT
ON
TENT CATERPILLARS.

By M. V. SLINGERLAND

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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The regular bulletins of the Station are sent free to all who request them.

CORNELL UNIVERSITY, ITHACA, May 22, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: Responding to your request of the 15th inst., for suggestions as to the controlling of the forest caterpillar, which has appeared in such numbers in Scoharie and Otsego Counties, I herewith submit a bulletin of advice by Professor Slingerland. Professor Bailey has already sent Mr. H. P. Gould, our expert in spraying, into the affected districts. It is now too late, however, to avert the calamity of this year, but it is hoped that the people may be awakened for action during the coming winter and next spring. This emergency bulletin is submitted to be issued under Chapter 430 of the Laws of 1899.

I. P. ROBERTS,
Director.

TENT CATERPILLARS.

Commissioner of Agriculture Wieting, reports in a recent letter to Director Roberts that many orchards, in the eastern part of the State are overrun with forest tent caterpillars. The writer is also receiving daily from village authorities in eastern New York, appeals for aid in destroying the vast hordes of the hairy caterpillars of the same insect which are defoliating thousands of beautiful shade trees, especially maples, in many village streets. A trip to Oneonta convinced us that an alarming state of affairs exists wherever this insect occurs in such almost incredible numbers as we saw on many of Oneonta's fine maple shade trees. Thousands of the shade trees in many New York villages are doomed unless prompt measures are taken to destroy the caterpillars, or "maple worms," as many call them. We began making observations upon this insect last year, when it stripped the leaves from many maple sugar groves in our State, and we have been watching it this spring, when it seems to be more numerous and destructive all through the state than in many years.

Our studies are not yet completed, but there is such a general call for information regarding the insect that this preliminary report, or emergency bulletin, has been hastily prepared to meet the demand. We expect to publish a full account of the forest and the apple tent caterpillars, and will also discuss cankerworms in the near future.

THE APPLE-TREE TENT CATERPILLAR.

Many are familiar with the common apple tent caterpillar (shown in figure 101), its work, and especially its large silken tent which a colony of the caterpillars spin and use as a nest or home. These tent caterpillar nests have been altogether too conspicuous objects in the nearby landscape in most parts of our state during the past two years. It is the work of only a few moments to wipe out with a rag, or burn out one of these tents with its writhing mass of worms. The sooner this operation is performed after the nest is begun, the easier and more effectual will it be. Wild cherry trees along roadsides should be destroyed, for they are a favorite breeding-place for the apple tent caterpillars, fall web worms, and other injurious insects.

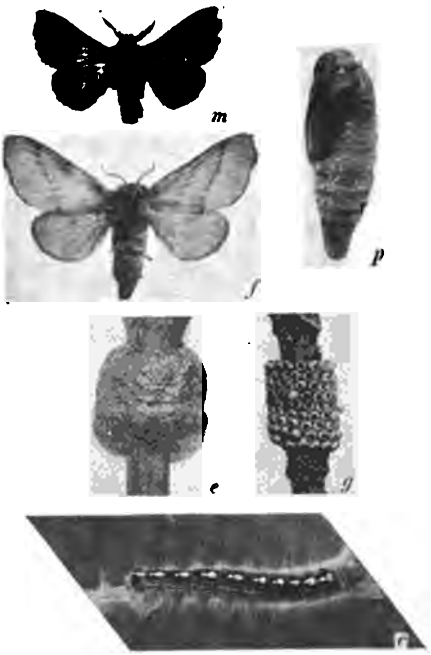
Our orchardists should learn to familarize themselves with the egg-masses of the apple tent caterpillar, for one of the easiest and most effectual methods of controlling the pest is to collect and burn these egg-masses at any time between August and the following April; the egg-mass is very similar to, but a little larger than that of the forest tent caterpillar shown at *e* in figure 102. Pay the boys and girls a few cents for each score or hundred of the egg-masses they collect; you will be doubly repaid when spring opens by a decided scarcity of caterpillar nests to wipe or burn out. Those who spray their orchards thoroughly with Bordeaux mixture, to which Paris green or some similar poison has been added at the rate of one pound to 150 gallons of the Bordeaux, report little trouble in controlling apple tent caterpillars by this method alone. Caterpillar nests are usually a scarce article in orchards which have had three thorough applications of the above spray. The first application should be made just before the blossoming period, when the caterpillars are very small and require but little poison to kill them; the second spraying should follow as soon as the blossoms have fallen, and a third application is usually necessary and advisable about a week or ten days after the second. Unless canker-worms occur in extraordinary numbers in an orchard,

101.—*A trio of Apple Tent Caterpillars, natural size.*

not many of them will live through the three applications above specified, if they are thoroughly made, and the same statements will apply to the forest tent caterpillars.

THE LIFE-STORY OF THE TENT CATERPILLARS.

In order to combat an insect pest the most effectively, one should know its life-story. This story of the lives of the apple and forest tent caterpillars may be briefly told by the aid of the pictures in figure 102. These two tent caterpillars are distinct kinds of insects but are very nearly related to each other and each has practically the same general life-history, differing only in some details of habits. The story of the Apple-tree Tent Caterpillar (*Clisiocampa americana*) has been interestingly told in the Teacher's Leaflet No. 5, which anyone can get free by applying to the Bureau of Nature-Study, College of Agriculture, Ithaca, N. Y.

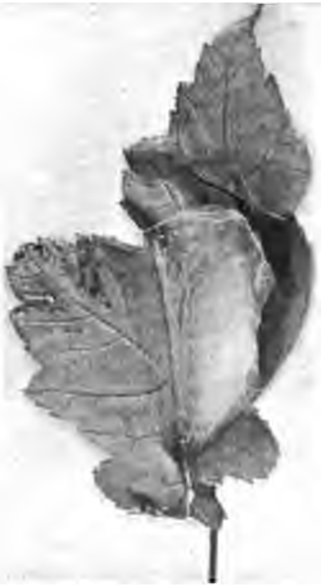


102.—*The Life-story of the Forest Tent Caterpillar. m, male moth ; f, female ; p, pupa ; e, egg-ring recently laid ; g, hatched egg-ring ; c, caterpillar. Moths and caterpillars are natural size, and eggs and pupa are slightly enlarged.*

At the date of writing (last week in May), the forest tent caterpillars (*Clisiocampa disstria*) are nearly full grown ; the picture at *c* in figure 102 was recently taken from life. In about two weeks, or early in June, the caterpillars will be seen wandering about seeking a suitable place to undergo their wonderful transformations. They may select a leaf on or under the tree on which they fed, as did the one shown in the frontispiece, or some angle in your house or rail-fence may afford a more suitable place. Here the caterpillar will begin to spin about itself a white shroud or cocoon, composed of silken threads, in which are mixed the hairs from its own body and the whole is given a powdery appearance by the caterpillar ejecting a liquid which becomes a yellowish powder upon drying. A cocoon is shown in figure 103.

Within this cocoon the caterpillar soon changes to the curious brown object—a pupa—shown at *p* in figure 102. In about ten days or two weeks after the cocoon is spun, or during the latter part of June, there emerges from it the adult insect—a buff-brown colored moth marked with a slightly darker band across each front wing; *m* and *f* in figure 102 represent the male and female moth respectively. The moths fly mostly at night and are often attracted to lights.

Soon after emerging, the female moths deposit their eggs in masses of about two hundred each around the smaller twigs, as shown at *e* in figure 102. The eggs are covered with a varnish-like substance; at *g* in figure 102 is shown an old, hatched egg-mass with the varnish-like coating worn off. The eggs thus deposited early in July will remain unhatched until the following April. Thus there is but one brood of the caterpillars in a year.



103.—*Cocoon spun by a Forest Tent Caterpillar in a maple leaf, natural size.*

A very important difference in habit between the forest and the apple tent caterpillar should here be emphasized. It is this: A colony or family of forest tent caterpillars hatching from the same egg-cluster, like their near relatives, work and live together during most of their life *but they never make any tent or nest.* The only approach to a web made by the forest tent caterpillars is a thin carpet spun on the bark or sometimes over several terminal leaves on which the whole family usually rest in a cluster (as shown in figure 104) during the day or when they are shedding their skins.

METHODS OF COMBATING THE FOREST TENT CATERPILLAR.

Fortunately both the apple and the forest tent caterpillars are preyed upon by many enemies, including insects, spiders, toads and birds. Where the forest tent caterpillars confine their work to their native haunts—the forest trees—we must depend largely upon these natural enemies to hold the insect in check. That these enemies are capable of doing this is evidenced by the fact that this insect usually appears in alarming numbers only at long intervals and its outbreaks usually last only a few years, as their enemies soon reduce their numbers to the normal. We visited several maple "sugar bushes" last year where the caterpillars had just finished stripping the foliage from all the trees, and we never saw so many parasitic foes; the little Ichneumons and Tachina flies were surprisingly numerous and busy getting in their deadly work on the caterpillars. Most owners of "sugar bushes" will have to depend on these little friends to check the depredations of the forest tent caterpillars, because it would usually be too expensive a job for an individual owner to undertake to combat the pest in his sugar grove. We hope and believe that the enemies of the caterpillars can be depended upon to get the upper hand and control the pest in the forests and sugar groves of New York in a year or two.

Where the forest tent caterpillars are present in alarming numbers in fruit or shade trees, however, the case is very different, and man should take prompt measures to check their ravages. In orchards the methods of gathering the egg-clusters and spraying with Bordeaux and Paris green, discussed on a previous page, will usually control the forest tent caterpillars. The presence of these caterpillars is not so readily discovered because they erect no tent or "signboard" in the tree as does the apple tent caterpillar. The two kinds of caterpillars often occur in the same tree.

The control of the forest tent caterpillar on village shade trees is a special problem, but not a difficult one, we believe. Enlist the aid of the school teachers, and the school children will soon become an invaluable army to help in protecting the trees. Let a few public spirited citizens or the village Board offer a prize to those pupils who collect over a certain number, say 1,000 or 10,000 of the unhatched egg-clusters at any time between August 1st and April 1st of the following year; or pay the children a certain sum, a few cents for every hundred unhatched egg-clusters collected. All egg-clusters collected should be burned. The rivalry between the children will soon spread to rivalries between schools and the result will be that the number of the caterpillars will be reduced to the minimum by a single season's crusade of the children; and what may be of more value still is the fact that the teachers, children, and many citizens will get lots of fun out of the warfare and all cannot help but learn a very instructive lesson in Mother Nature's ways.

The above suggestion is not a theory, for just such a crusade has been successfully carried out even in so large a city as Rochester, N. Y. We believe there is no cheaper and more instructive method of controlling these forest tent caterpillars in village shade trees. Begin the warfare in August or September, 1899, or better, after the leaves have fallen so that the eggs can be more easily seen on the twigs, and keep it up until the last egg-cluster is burned before April 1st, 1900. Let the beautiful and valuable shade trees begin the new century free from the devastating caterpillars.

Shade trees can be, and have been, sprayed with a poisonous mixture and these forest tent caterpillars killed thereby. But the spraying must be done early in the spring after the little caterpillars hatch, when the first leaves are unfolding; and to spray large shade trees requires very expensive ($250.00 at least) apparatus, and experienced men to operate it. It is the nastiest kind of work, and the chemicals would be quite an item. Hence it is doubtful if spraying could be successfully employed to control these caterpillars in many villages. When the caterpillars get half or two-thirds grown as they are now (last week in May) they are so large that it would be a very expensive matter to feed them enough Paris green to kill them. We believe it would be cheaper, easier and more effectual, to either enlist the children, or to carry on a vigorous warfare against the nearly full grown caterpillars during the latter part of May and the first week or two in June along the following lines:

Colonies of the caterpillars can be seen at almost any time of day clustered together on the bark of the trunk or large branches of the infested trees. Such a cluster of caterpillars is shown in figure 104. The apple tent caterpillar may usually be found in its nest during the day, but its forest relative makes no such retreat or home. Where these clusters of caterpillars occur in reach on the trunks of the trees it is an easy matter to sweep them off and crush them. It is also an easy matter to dislodge the clusters occurring high up in the tree on the branches. One has simply to climb the tree with a padded mallet and suddenly *jar* (shaking will not do) the branches on which the caterpillars are clustered, when nearly every caterpillar will drop to the ground as if shot, some spinning down by a silken thread, which, however, they seem to be unable to ascend as a canker-worm does. One should not be satisfied with jarring the caterpillars onto the ground, but a sheet or canvass should have been previouslyspread beneath the tree, and someone employed to at once sweep the caterpillars into some receptacle where they can be burned or otherwise destroyed. Two men could thus remove and destroy nearly all the forest tent caterpillars on a large shade tree in a few minutes, and thus stop the breeding of the insect for the next

104.—*A family of Forest Tent Caterpillars resting during the day on the bark, about one-third natural size.*

season. This jarring method is also applicable to orchards, and is in fact the only practicable method to reach the caterpillars after they are half or two-thirds grown, or after May 20th in most localities in our state. The method can be practiced by individual owners of fruit or shade trees, but where village shade trees are infested, we would recommend that the village authorities hire two or more men, equip them with padded mallets, brooms, and sheets, and have them make a business of examining every shade tree and killing the caterpillars. All of the shade trees in a village could be thus gone over in a few days and millions of the caterpillars destroyed before they can transform. A second scrutiny of the trees by the same gang of men a few days later would doubtless pay. One hundred dollars expended in this way, *now*, by a village, to combat these caterpillars would not be felt by the individual taxpayers, and would doubtless result in saving the lives of shade trees worth ten times this amount. It would not be advisable to trust to individual property owners to jar their trees, for many would not do it, and thus would breed a crop of the caterpillars for their neighbors the next season.

Cotton batting, coal tar, or similar bands put on trees to prevent the caterpillars from crawling up, will avail but little in reducing their numbers, for only those which fall from the trees or happen to wander from the defoliated trees will thus be kept from going up.

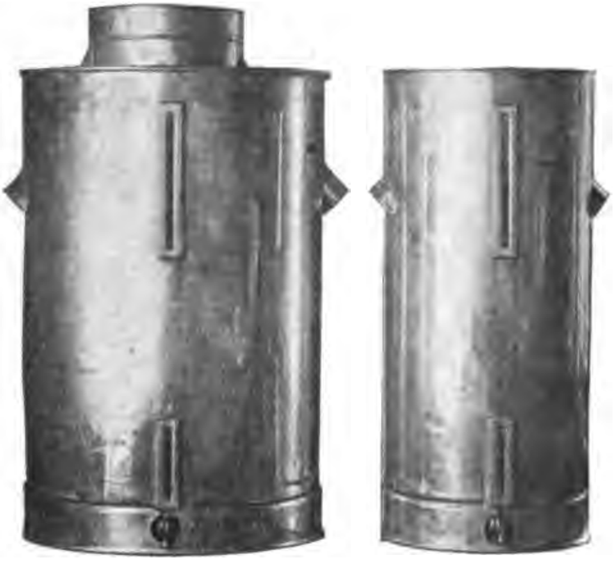
These hordes of tent caterpillars which are now ravaging shade and fruit trees in our state can be readily controlled if prompt and intelligent action be taken.

M. V. SLINGERLAND.

Bulletin 171. **July, 1899.**
Cornell University Agricultural Experiment Station.
ITHACA, N. Y.

DAIRY DIVISION.

CONCERNING PATENTS ON
Gravity or Dilution Separators.



By **HENRY H. WING.**

PUBLISHED BY THE UNIVERSITY,
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1899.

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CONCERNING PATENTS ON GRAVITY OR DILUTION SEPARATORS.

In Bulletin No. 151 published in August, 1898, the efficiency of these creaming devices was summed up as follows:

"Gravity or dilution separators are merely tin cans in which the separation of cream by gravity process is claimed to be aided by dilution with water.

Under ordinary conditions the dilution is of no benefit. It may be of some use when the milk is all from 'stripper' cows, or when the temperature of melting ice cannot be secured.

These cans are not 'separators' in the universally accepted sense of that term and cannot rank in efficiency with them.

They are even less efficient than the best forms of deep setting systems, such as the Cooley Creamer.

They are no more efficient than the old fashioned shallow pan; but perhaps require rather less labor."

These conclusions have since been abundantly confirmed though there seem to be many who desire to use these cans on the score of the less labor required even though there may be in most cases some loss of fat.

One of the chief misleading features used by the promoters of this system is the way in which the term separator is used to imply that the dilution process is equal in efficiency to a centrifugal separator. This is well shown by the following quotation from a recent circular of the "Wheeler's Gravity Cream Separator."

"Those that keep only one or two cows, as well as the large dairyman, can have the advantage of a separator at a small cost, compared with the centrifugal separator or creamer."

In another way would-be users of the dilution process are being mislead and this is in regard to the patents that have been issued or applied for on the dilution process or on the various styles of cans in which it is to be used. At the present time certain parties are going about the state claiming a royalty from any who may be using the dilution process in any form of can but their own. The following is a type of the inquiries we are receiving concerning the matter.

————N. Y., MAY 26, 1899.

Cornell University Experiment Station :

There is in this vicinity an agent for the Wheeler Gravity Separator, who is trying to stop us from using every other separator or can of every description except his own, claiming that his manufacturer has a patent on the process, and that we have no right to mix water with our milk for the purpose of raising the cream, except by using his cans or by paying a royalty to his manufacturer. Respectfully,

————

This and similar inquiries have led us to make a careful examination of the files of the *Patent Office Gazette* and we find that during the past year numerous patents have been granted on various forms of gravity separators and creaming cans. Briefly described they are as follows:

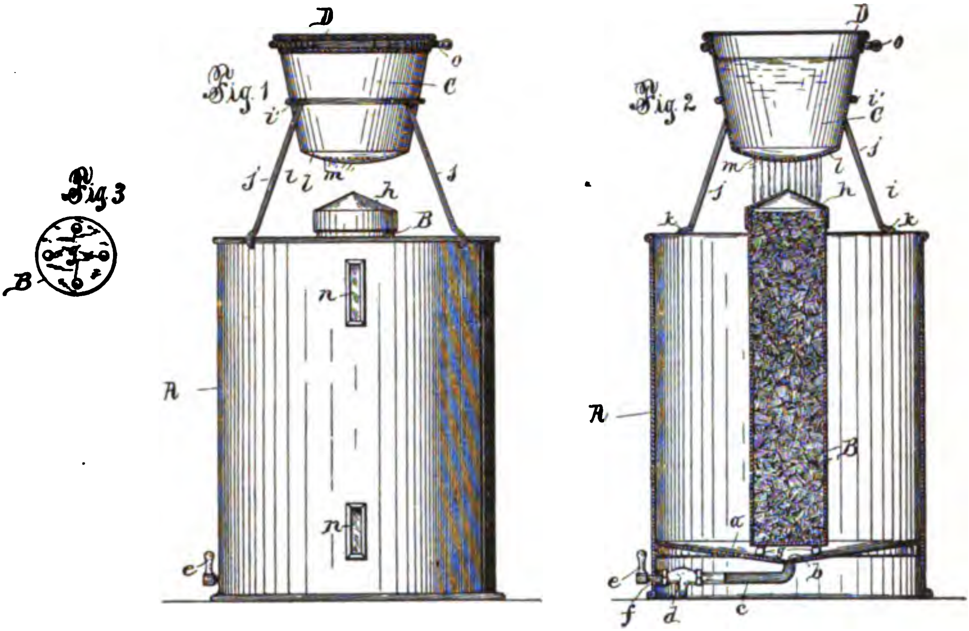
THE AQUATIC CREAM SEPARATOR.

This is manufactured under patent No. 605,252, granted June 7, 1898, to C. L. and F. G. Lee. Its character is shown by the following extract from the specifications and the claim under which the patent was granted.

"The improved results obtained by our apparatus are as follows: The milk is poured through the strainer D into the aerator C, whereby the sediment is removed therefrom. The milk then passes through the perforated bottom *l* of the aerator and is sprayed upon the conical top of the cover *h* of the cooler B, whereby it is deprived of its animal heat, and thence passes down the outside of the cooler. It is then allowed to stand until the temperature thereof is reduced sufficiently in order to prevent congealing of the same. The milk is then diluted by the introduction of water and is allowed to remain tranquil a sufficient period of time to allow the cream to rise to the top thereof, which action can be readily ascertained by means of a sight-glass *n*, secured in the side of the can A."

"What we claim is—

An apparatus for separating cream from milk comprising a milk-can provided with a centrally-depressed bottom and having an outlet in the center of said bottom, a cooler within said can and provided on its bottom with feet supporting the cooler over said outlet with passages under the cooler, said feet serving to prevent eddying of the outflowing liquid and causing a draft of said liquid equally from all sides of the can to the outlet and also promoting the discharge of the sediment from the bottom of the can substantially as described."



1.—*The Aquatic Cream Separators.*

It will be seen that the peculiarity of this apparatus consists in the central cooler supported upon little legs over the outlet in the center of the bottom of the can and that while dilution is mentioned in the specifications as essential to the "improved results" the claim is on the form of the can only and not upon the dilution. As a matter of fact this "separator" was at first made without legs to the cooler and with the outlet at the side, thus entirely ignoring the claim. A recent letter from the manufacturers says, "We are making the 'Aquatic' Cream Separator under patent No. 605,252, granted June 7, 1898. We also manufacture cheaper cans for the dilute process, but of course know that they will not do as good work."

THAYER'S CREAM SEPARATOR.

This constitutes patent No. 608,311, granted August 2, 1898, to Julius W. Thayer of Milton, Iowa.

The following extract from the specifications shows that dilution is considered an important part of the process though nothing whatever is said about it in the claim.

"In operation the milk while warm (as immediately after milking) is strained and introduced into the receptacle, after which water at a lower temperature than the milk (and preferably at a considerably lower temperature) is introduced through the tube 8 and gains access to the interior of the receptacle at the lowest point thereof. Obviously the extension of the inlet-tube approximately throughout the longitudinal center of the bottom of the receptacle has the effect of chilling the contiguous portions of the contents, and as the water enters and commingles with the milk the chilling thereof results in the separation of the cream which, rising to the top, remains supported by the heavier contents of the receptacle until the latter have been withdrawn through the faucet. The mixture of milk and water may be withdrawn to lower the level of the under surface of the cream to the most depressed point of the bottom of the receptacle, this point in the operation being visible through the sight-pane.

"It will be seen that in addition to the advantage gained by introducing the cooling agent at the lowest point of the bottom of the receptacle the inclination of the longitudinal center of said bottom and the lateral inclination of the side portions of the bottom have the effect of concentrating a lower stratum of the contents contiguous to the faucet, whereby in drawing off the milk almost the entire quantity thereof may be removed without disturbing the cream. The usual time necessary for accomplishing the complete separation of the cream from the milk is from twenty to thirty minutes, as I have discovered in practice."

"Having described my invention, what I claim is—

1. A cream-separator having a receptacle provided with a bottom of which the side portions are inclined downwardly and inwardly to the longitudinal center thereof, said longitudinal center being inclined downwardly from the rear toward the front wall of the receptacle, a faucet communicating with the receptacle at the most depressed point of its bottom, and an inlet-tube having an exposed inlet end, and an extension 9 arranged within the receptacle upon the inclined longitudinal center of its bottom, with its outlet end located contiguous to the said most depressed portion of the bottom of the receptacle, substantially as specified.

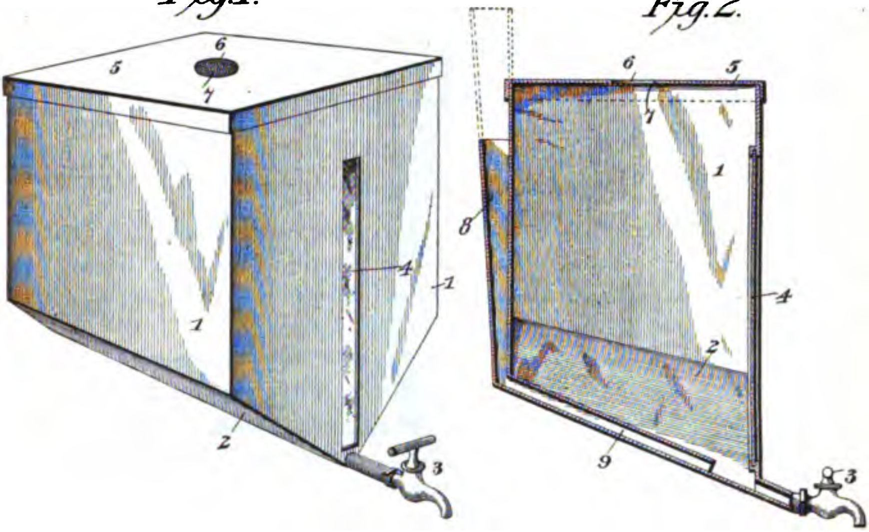


Fig. 1. Fig. 2.

2.—*Thayer's Cream Separator.*

2. A cream-separator having a receptacle of which the bottom is inclined laterally from the side walls toward a central longitudinal line, this longitudinal center being inclined downwardly from the rear toward the front wall, a removable cover fitted upon the receptacle and provided with a ventilating-opening fitted with a gauze screen, a faucet communicating with the interior of the receptacle at the lowest point of its bottom, a vertical sight-pane through which the contents of the receptacle may be observed, and an inlet-tube having an exposed inlet end, and arranged at its outlet end contiguous to said depressed point of the bottom, an intermediate portion of the inlet-tube extending through the receptacle, substantially as specified."

The peculiar feature of this "separator" seems to be the tube through which the water is added. A letter addressed to the inventor was returned undelivered and it is not likely that this machine is on the market.

PHILLIPS' CREAM SEPARATOR.

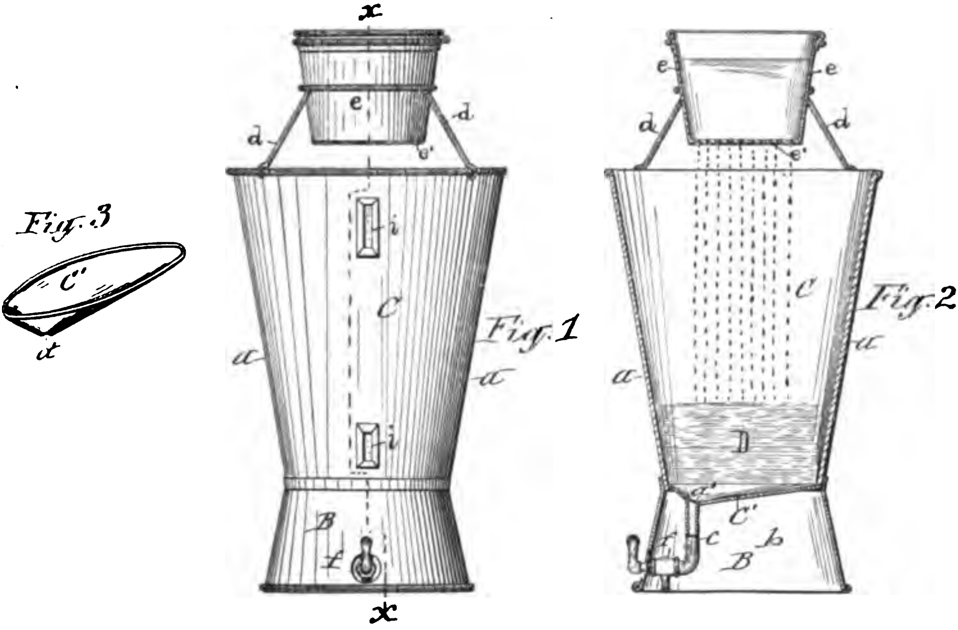
The patent on this "invention" is No. 609,461; it was granted Aug. 23, 1898, to John E. Phillips, Central Square, N. Y., and its operation and the claims for the patent are described in the following fanciful language:

"By practical tests it has been found that the separation of the cream from the milk is promoted by dilution of the milk, and this has been usually done by pouring water into the milk at the time of setting the same to allow the cream to rise to the surface of the diluted milk.

"The object of my present invention is to effect the separation of the cream from the milk more perfectly and expeditiously by dilution of the milk during the process of separating the cream therefrom; and to that end the invention consists in causing the milk containing the cream to fall in separate drops upon the surface of a tranquil body of water or suitable diluting liquid, and thereby diluting each drop separately and causing the cream thereof to be gathered on the surface of said liquid during the dilution of the drop. Said drops falling upon the water in the can, each drop is diluted separately and the cream thereof is detained upon the top of the water, while the milk becomes com-mingled with the water. In this manner the process of separating the cream from the milk is very much expedited and the separation is rendered more positive and effectual."

"What I claim as my invention is—

The within described process of separating cream from milk by specific gravity, consisting in causing the creamy milk to fall in separate drops through the air onto the surface of a tranquil body of diluting liquid, and thereby diluting each drop separately, and by the gentle diffusion of the milk of the successive drops in the diluting liquid causing the cream thereof to become separated from the diluted milk and form a stratum of cream upon the surface of the tranquil liquid, and subsequently drawing the diluted milk from under the supernatent stratum of cream as set forth."

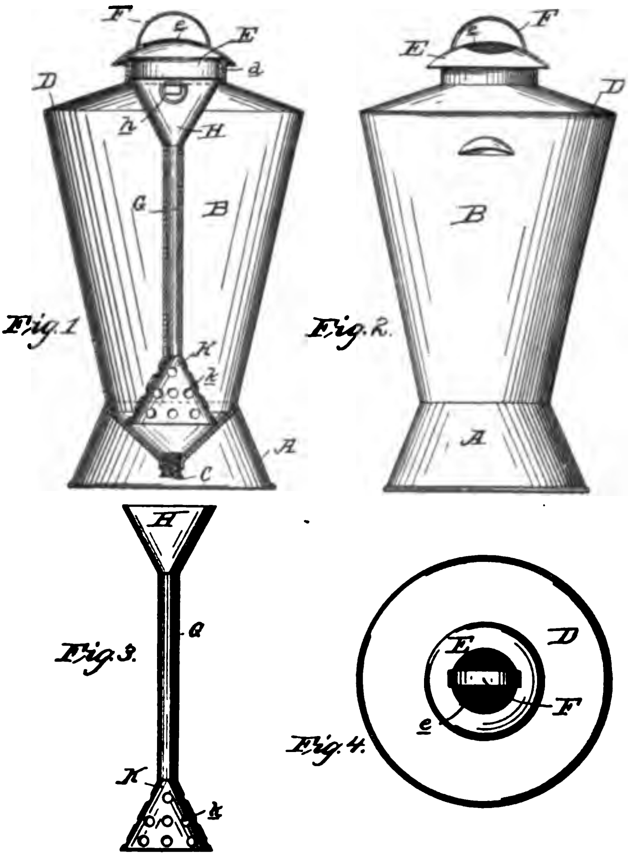


3.—*Phillips' Cream Separator.*

Without raising the question of the advantage or disadvantage of diluting "creamy" milk, would-be users of the dilution process may be assured that they are in danger of in fringing the Phillips patent only when they "dilute each drop separately." However desirable it may be to "dilute each drop separately," it is extremely doubtful if it can be done even by using the Phillips can.

RECTOR'S CREAMING CAN.

The patent on this can is No. 611,275. It was granted Sept. 27, 1898, to Jas. A. Rector, Lancaster, Mo. The peculiar feature of this can seems to be the central tube or "distributing head"



4.—*Rector's Creaming Can.*

through which the water is introduced. While dilution with water is an essential feature of the operation of this can, as is seen by the following extract from the specifications, it will be further noticed that nothing whatever is claimed for dilution in the "claim" under which the patent is granted.

"In operation the milk is first placed in the can. The distributing device is then inserted. Water of low temperature is afterward introduced into the funnel at the top of the distributer. The water, being cold, immediately settles to the bottom, and being distributed regularly through the apertures of the distributing-head of the distributer, rises through the bottom of the can, carrying the particles of cream upward, while the blue milk is assimilated, the cream floating on the top. The milk is allowed to stand in this condition for a few moments, and the water and blue milk are then drawn off through the opening in the bottom of the can, leaving the cream in the can, from which it may be drawn at any time through the bottom opening.

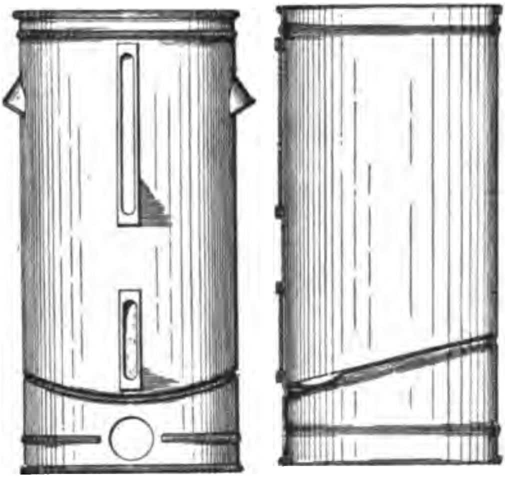
"I have found that cream can be separated from the milk very rapidly by this means and with but little trouble, the animal heat of the milk passing off through the perforated top."

"Having thus described the invention, what is claimed, and desired to be secured by Letters Patent, is

In a creaming-can the combination with the can-body having a conical base formed with a discharge-opening in its apex, and a neck,of a distributing device located wholly within the can and consisting of a tube having a funnel-shaped upper end positioned in the neck and a perforated distributer at the lower end of the tube resting on the bottom, substantially as described."

WHEELER'S GRAVITY CREAM SEPARATOR.

Although several rivals secured patents earlier, this is claimed to be the only "true and original" gravity separator. On Nov. 22, 1898, a patent (No. 29,715) was issued to G. T. Wheeler, Mexico, N. Y., on the *design* for a can as shown in the cut. So far as we have been able to discover the only novel feature of this can lies in the fact that the bottom is both curved and slanting. Up to August, 1898, this separator was made and sold with a flat bottom, so that the peculiar shape of the bottom cannot be considered as essential even by the "inventors."



5.— *Wheeler's Gravity Cream Separator.*

It is this concern that has been most strenuous as to the advantages of dilution and their extravagant claims as published in Bulletin No. 151, have been frequently copied and adopted by the manufacturers of the other styles of cans. It is the agents of the Wheeler separator too, that we have most frequently heard of as claiming a patent on the process of dilution and demanding a royalty therefor. We are personally assured by the manager however, that they are not now claiming a patent on the process and are so instructing their agents.

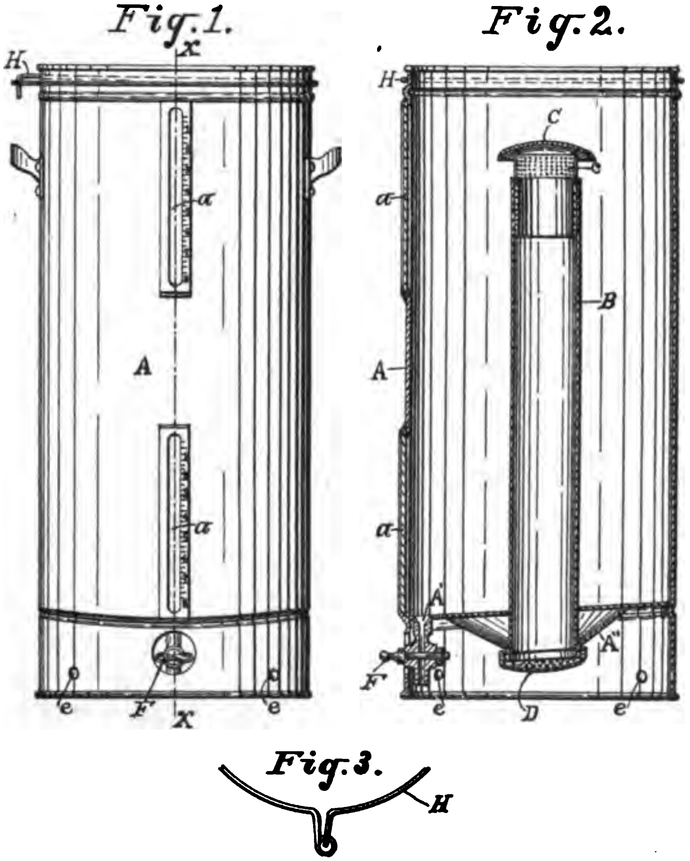
HUNT'S CREAMING CAN.

The patent on this can is No. 619,753 and it was granted Feb. 21, 1899, to Henry S. Hunt, Cato, N. Y. Its essential features are shown in the following extract from the specifications and the claim in full:

"In operation my invention of improved creaming-can is used as follows: Equal quantities of milk and water are placed in the vessel A, being run through a straining cloth secured over the top of the can, and the mixture is permitted to stand in the vessel A until the cream rises thereon, during which time the cap C is held in the position shown in Fig. 2, where the wire-cloth *c* is elevated above the tube B, so as to permit the free passage of air through said tube B for the purpose of providing a sufficient draft to carry off any deleterious gases which might arise from the milk and water, or which might otherwise be permitted to contaminate the cream."

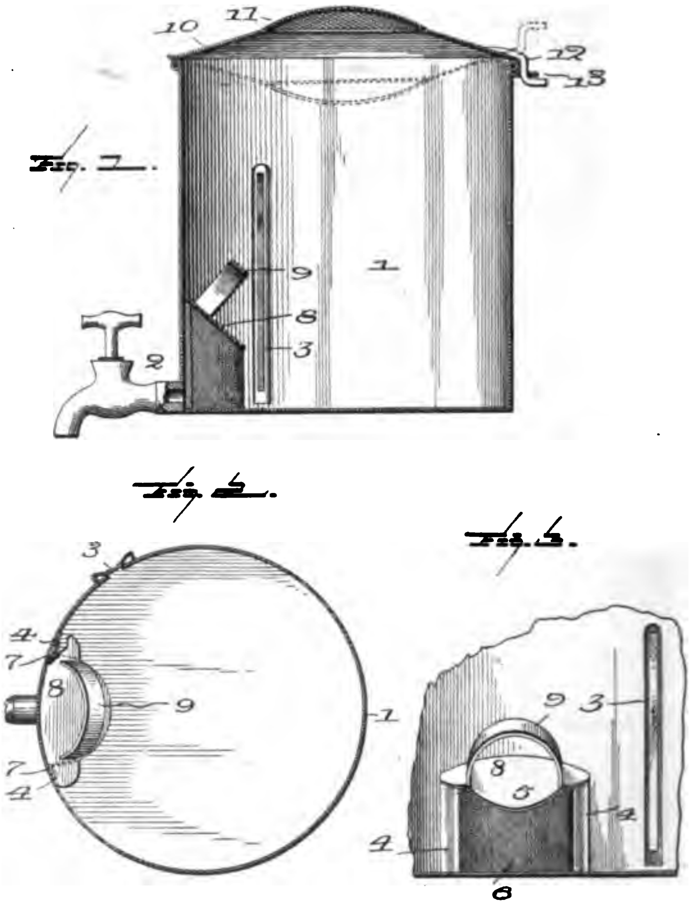
"Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

In a creaming-can, the cylindrical shell A, provided with a bottom which slopes toward one side, and which is raised a suitable distance above the lower end of the shell, a faucet secured to the bottom and inclosed by the chamber in the lower end of



6.—*Hunt's Creaming Can.*

the shell, and a central draft-tube which extends vertically in the shell within a short distance of its top, and which tube has its lower end to extend a suitable distance below the bottom, and which tube has its lower end braced by the portion A (see cut), combined with a perforated cover D which is placed over the lower end of the tube, and the cap C placed above the end of the tube and provided with suitable perforations, substantially as shown and described."



7.—*Rosback's Cream Separator.*

It will be noticed that nothing whatever is said in the claim as to dilution and that the peculiar feature of the can rests in the "ventilating" tube passing through the middle of the can. This feature in actual practice has not only proved to be of no advantage but is a decided nuisance in washing and handling the can.

ROSBACK'S CREAM SEPARATOR.

This is a can patented by Joshua A. Rosback, Hermon, N. Y. The patent is No. 624,100 and was granted May 2, 1899. As will be seen by the extracts below, while dilution is recommended, the claim for the patent covers only the form of the strainer over the port to the faucet.

"The mode of practicing the invention is as follows: The milk is taken direct from the cow and placed in the can, and an equal amount of fresh cold water is added. The can is then placed in a cool place and is permitted to stand. The cream will rise to the top and the milk and water will settle to the bottom of the can."

"Having described my invention, what I claim as new, and desire to secure by Letters Patent, is—

A cream-separator consisting of a can, a faucet located near the bottom thereof, a convexed strainer located over the port to the faucet, the top of said strainer being imperforate and slanting at an angle toward the center of the can."

DOTY'S CREAM SEPARATOR.

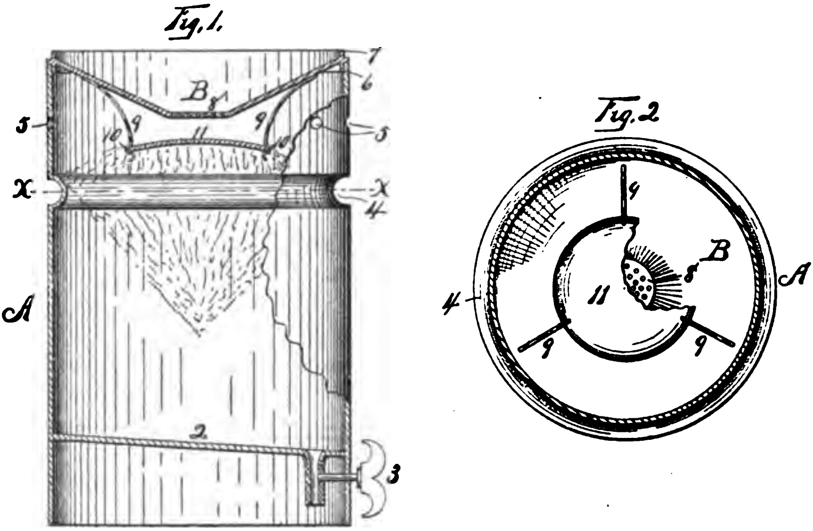
This was patented May 2, 1899, by Ellsworth P. Doty, Cato, N. Y., and bears the number 624,194. This like all the others mentions dilution as a part of the process, but the claim is only on an unimportant part of the can as the following extract from the specifications shows.

"The milk poured into the concave top or hopper is strained, falls onto the sprayer, flows over its surface, is discharged from its edges in streams, more or less of which fly against the convexity or neck-wall of the can and are thereby broken up into drops, which are deflected toward the center of the can or flow down over its innner walls and are thereby thoroughly aerated, the heated or displaced air flowing out through the vents, carrying with it the animal odor of the milk.

"If water is used to dilute the milk and expand the cream-globules to facilitate or quicken the raising of the cream, a sufficient quantity is first placed in the can and the milk falls into it."

"Having described my invention, what I claim, and desire to secure by Letters Patent, is—

In a cream-separator, the combination with a can having a constricted neck of a reversible concavo-convex cover having upward and downward flanges adjacent to its edge and in alinement with each other, a strainer at the center of said cover, spring-fingers separately secured to the convex side of said cover on converging lines and diverging from it, and a concavo-convex sprayer removably supported by said fingers adjacent to said extremities whereby the milk is thrown from said sprayer against said constricted neck and is thereby broken up."



7 —*Doty's Cream Separator.*

In addition to these, two patents on designs have been recently issued, one, 30,741, on May 9, 1899, to Simon Reinsberg, Quincy, Ill., for a distributor similar to Rector's, the other 30,962 on June 6, 1899, to Frank C. Hawkins, Breesport, N. Y., for the bottom of a can similar to Wheeler's.

A striking similarity is observable in all these patents. In none of them except Phillips' is dilution mentioned in the claim, and there it covers not the dilution itself but the manner of it. In all of them, however, dilution is mentioned in the description as an essential part of the process. It would seem, therefore, that in patenting some minute or unessential feature of the can these people have sought to convey to the uninformed the idea that the whole can, process and all was subject to the patent. This is further borne out by the attempt in some cases to collect royalty from people using the dilution process in Cooley or other cans. Since some manufacturers have stated that an application has been made for a patent covering the process of diluting milk with water to facilitate the raising of the cream, it may be well to look into the matter of the possibility of such a patent being granted.

In the language of the patent office an invention, in order to receive a patent, must present "novel, useful, and patentable subject matter." Waiving altogether or granting entirely the usefulness and patentability of this process let us look only into its novelty. The process was certainly well known as early as 1890, for in that year it was the subject of investigation and report by at least three Agricultural Experiment Stations* in widely separated parts of the country. It has been argued that these reports, since they did not recommend the practice, should not be considered as evidence that the process was "well known and in common use." But one, at least, of the publications cited† did strongly recommend the process; and if recommendation were necessary to constitute publicity it would be easy to find it in the agricultural and dairy press of that period. The late Col. F. D. Curtis, to the personal knowledge of the writer, strongly recommended the dilutive process at numerous farmers' institutes in this state during the winters of 1889–90 and 1890–91, and frequently also recommended it in the press.*

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*Vt. Agr. Expt. Sta. Newspaper Bulletin No. 3; Cornell Univ. Agr. Expt. Sta. Bull. No. 20, and Univ. of Illinois Agr. Expt. Sta. Bull. No. 12, p. 376.

†Vt. Agr. Expt. Sta. Bull. No. 3.

Prof. E. F. Ladd, then of the State Agricultural Experiment Station at Geneva, now of the North Dakota Agricultural Experiment Station, also recommended† it under certain conditions, and it was frequently mentioned by other writers. It is also recommended for use in connection with the Cooley creamer in circular No. 214 of the Vermont Farm Machine Co., page 10. Under date of May 31, 1899, Mr. N. G. Williams, the manager of the company, informs me concerning the above. "These particulars were in April, 1890, and have been published in our circulars ever since. We had recommended it (dilution) before this." The process was then well known over large portions of the country at least nine years ago, but had almost completely disappeared from public view till revived by these boomers of patent cans about two years ago.

CONCLUSIONS.

Several patents have been granted covering unimportant details of the construction of cans in which the dilution of milk with water is recommended to facilitate the separation of the cream.

Anyone desiring to use this process of doubtful utility is perfectly free to do so without let or hindrance from the holder of any patent right whatever.

The Cornell University Agricultural Experiment Station will esteem it a favor to be put in communication with anyone who is demanding a royalty from persons who are diluting their milk in order to facilitate the raising of the cream.

**Country Gentleman*, Dec. 12, 1889, p. 945; July 31, 1890, p. 611, and Aug. 21, 1890, p. 662.

†*Rural New-Yorker*, Aug. 16, 1890, p. 527.

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Bulletins Issued Since the Close of the Fiscal Year, June 30, 1899.

171. Gravity or Dilution Separators.

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Bulletin 172. **September, 1899.**
Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

ENTOMOLOGICAL DIVISION.

The Cherry Fruit-Fly

A

NEW CHERRY PEST

By M. V. SLINGERLAND.

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1899.

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THE CHERRY FRUIT-FLY.

Rhagoletis cingulata ? Loew.

Order DIPTERA; sub-family TRYPETINÆ.

The growing of cherries is already an important phase of the fruit industry of New York and neighboring states. And cherry orchards now frequently supplement the few cherry trees often seen in door-yards, in gardens, or along lanes and roadsides. Everyone who eats this luscious fruit when fresh is familiar with the fact that cherries are often "wormy." Most cherry growers now understand that the cause of "wormy" cherries is that arch enemy of the plum—the plum curculio, shown enlarged in figure 9.

9.—*The plum curculio, enlarged. The insect which "stings" or makes the crescent cut on the cherry, and is responsible for most "wormy" cherries.*

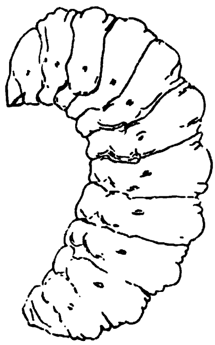
The crescent cut or "sting" of this little beetle is a very discouraging factor to the cherry grower; and the resulting white and footless grub, with a brownish horny head, which revels in the juicy fruit, is a familiar and distracting object to most housewives. In view of these discouraging facts, we are somewhat loath to announce to cherry growers, through the medium of this bulletin, that another, and possibly even a more serious insect enemy, has recently appeared in at least one Massachusetts and in several New York cherry orchards. This new cherry pest works in the fruit, as does the plum curculio, and while it is capable of being equally as destructive, it also works in a much more inconspicuous manner. One can usually readily determine when a cherry is "wormy" from the attacks of the plum curculio, but this new pest gets in its work in such a way that the fruit it infests might easily be classed among the fairest and best on the tree, or in the dish on our breakfast table.

From the above statements, cherry growers can readily understand how serious a menace to their business this new pest might easily become, and how important it will be for them to learn all they can about it.

As we made our first acquaintance with the pest only about two months ago, we have had no opportunity to fully investigate its habits, and hence cannot tell its life-story in detail. For the same reason, we have not tested any remedial measures to control it, but, fortunately, we have at hand the literature giving the results of experiments against similar insect pests working in the fruits of European countries and of our antipodal neighbors in Australia, New Zealand and South Africa. This bulletin is therefore simply a preliminary report for the purpose of calling the attention of cherry growers to this new pest, with an account of what measures have been used against similar pests, all with a view of helping the growers of cherries to understand the nature of the enemv and to be on the lookout for it.

CHARACTERISTICS OF THE NEW PEST.

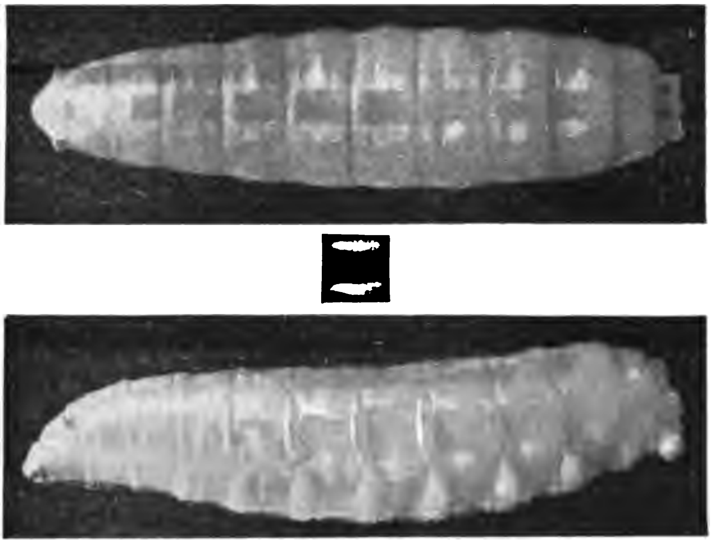
This new insect enemy of cherries is very different from the plum curculio, which has heretofore been justly accused of being the cause of all "wormy" cherries. The grub of the plum curculio is shown much enlarged in figure 10, while the "worm," which has been found in from one-fourth to one-third of the cherries on some trees the past summer, is shown, natural size and enlarged, in figure 11. As a comparison of these figures will show, this new cherry "worm" is quite different and can be easily distinguished from the *grub* (name applied to the larva of a beetle) of the plum curculio. This new cherry "worm" is instead a true *maggot*, a name given to the larvæ of the two-winged insects—the flies, like the common house-fly.



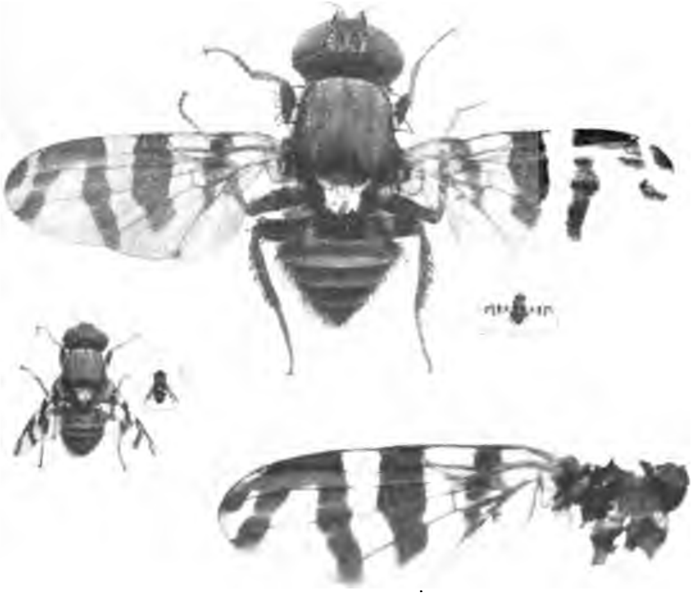
10.—*The grub of the plum curculio, enlarged. This is usually the culprit found in "wormy" cherries.*

The shape and size of these cherry maggots, when full-grown, are well shown in figure 11. They are of a very light yellowish-white color. From each side of the body near the head pro-

PLATE I.



11.—*Dorsal and lateral views of maggot of the cherry-fly. Natural size and much enlarged.*



12.—*Rhagoletis cingulata Leow. The fly which is supposed to be the adult or parent of the cherry maggot. The fly is shown natural size and enlarged, with wings spread and in the normal position when the fly is at rest. The enlarged wing below illustrates a variation in the markings.*

jects a minute, light-brown, fan-shaped organ, which is the cephalic opening of the breathing tubes; the caudal openings of these tubes or trachea form two peculiar, light-brown, slightly elevated, slit-like openings on the caudal end of the body. The mouth-parts consist of two black, minute, sharp, rasping jaws which usually project slightly from the pointed head.

We have as yet found no characteristics by which we can distinguish these cherry maggots from that common pest of the apple—the apple maggot. And we are not yet sure that this new cherry pest is not the apple maggot in a new rolé.

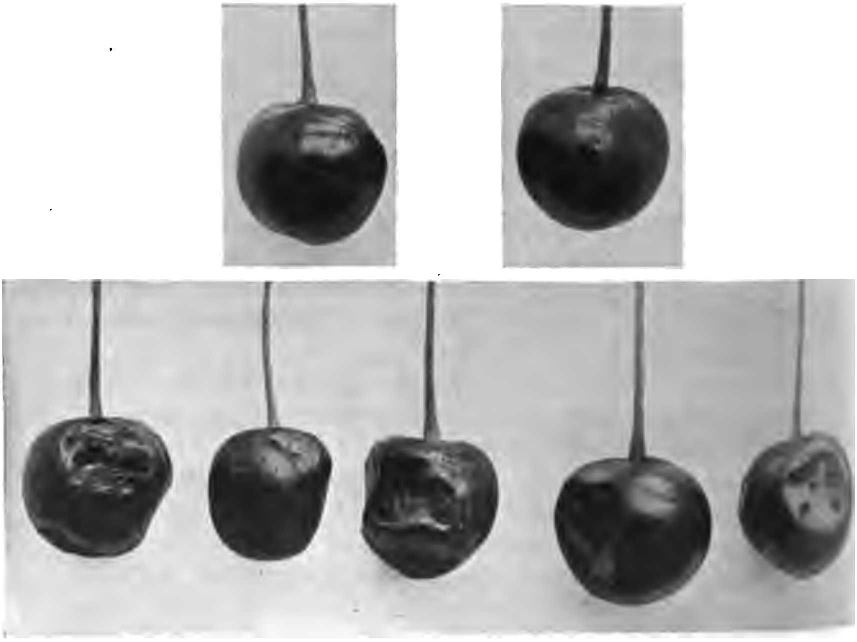
These maggots, which spend practically their whole life in the flesh of the cherry, are the only stage of the insect with which the consumers and most of the growers of the fruit will become familiar.

The maggots hatch from eggs laid by a pretty little fly, resembling in shape, but somewhat smaller than the common house-fly. We cannot know with absolute certainty just what kind of a fly is the parent of the cherry maggot until some of the maggots now in our breeding cages transform into the fly, and this will not take place until next spring. But for reasons to be given later on in discussing the identity of this new pest, we think that the adult form of it is the fly, shown natural size and enlarged, in figure 12. The body of this fly is black, and its head and legs are of a light yellowish-brown color; the lateral borders of the thorax are light yellow; the caudal borders of the segments of the abdomen are whitish; the wings and the scutellum are crossed by four blackish bands and have a blackish spot at their tip; this spot is sometimes confluent with the nearest band, as shown in the enlarged figure of a wing in the lower part of figure 12. The peculiar arrangement of these markings on its wings serves to easily distinguish this fly from any of its near known relatives.

One cherry grower tells us that he saw many of these flies on his trees when the fruit was being picked. He stated that the flies were then somewhat sluggish in their movements, often alighting on the picker's hand. Their black-banded wings render these flies quite conspicuous objects as they flit about from cherry to cherry, so that cherry growers should be able to familiarize themselves with the adult or fly stage of this new enemy.

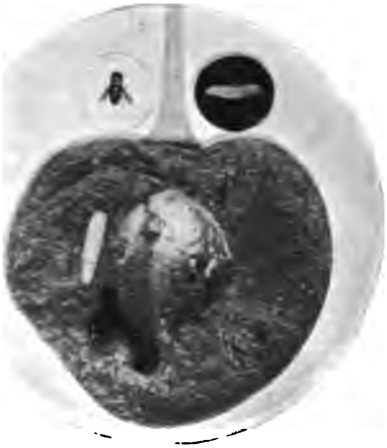
HOW AND WHEN THE INSECT WORKS.

Unfortunately this cherry maggot works in a very inconspicuous manner, so that it will be a difficult matter to determine its presence until the mischief is wrought. All of those who suffered from its ravages the past summer did not know of its presence until their attention was called to it by the consumers of the cherries. One grower picked two basketsfull of what seemed to be the fairest and largest cherries, and took them home for canning. When the housewife came to pit them she was much surprised and disgusted to find that many of them were "wormy" with these cherry maggots. The two cherries in the upper part of figure 13 contained maggots, although they were apparently perfect fruits externally. If the cherries are



13.—*Cherries infested by the Cherry Fruit-fly. All the cherries contained maggots, although the upper ones showed no external indications of being infested. Natural size.*

allowed to remain on the tree, or are not used within a few days after picking, the work of the maggot will result in a rotting and sinking in of a portion of the fruit, as is shown by the five cherries in the lower part of figure 13. When this stage is reached, or often even before the fruit shows signs of rotting, the maggots are usually full-grown and soon crawl out of the fruits. One lover of this luscious fruit reports that when some cherries which had been left over from a meal the preceding day, were placed on the table the next morning for breakfast, it was found that several maggots had crawled out during the night. He is now wondering how many maggots were unwittingly eaten the day before !



14.—*Section of a cherry, enlarged, to show the maggot and the nature of its work. The small figures above show the maggot and its supposed parent, the fruit-fly. Natural size.*

The work of this cherry maggot is well illustrated in the enlarged picture of a cherry in section, in figure 14. The maggots feed upon the juicy flesh of the ripening cherry, usually near the pit. They form an irregular, rotten-appearing cavity which is represented by the black cavity near the pit in figure 14. Until the maggots get nearly full-grown their work does not show on the surface of the fruit. Soon after "picking-time," however, the rotting extends to the skin which sinks in. Usually but a single maggot is found in a cherry; we have sometimes found a second, but always much smaller, maggot in the same fruit. The maggots do not tunnel all through the flesh of the cherry as does the apple maggot in apples.

We have had no opportunity to ascertain when this cherry maggot begins its work in the fruit. The maggot which works in cherries in Europe is said to begin work about the time the fruits are turning red, and there are indications that our new American pest begins about the same time. It is doubtful if the maggots feed more than three weeks in the fruit, and most of this must be done in the month of June. The maggots may begin their work in the latter part of May in early varieties of cherries, and we have found them in cherries left on the trees as late as August 5th. We also saw many of what we believe to be the adult insect on the cherries at this late date; Mr. Lowe reports finding young maggots in fruits as late as August 16th. Our Massachusetts correspondent reports that some of his cherries began to "spoil" even before they had fully matured.

VARIETIES OF CHERRIES ATTACKED.

The European cherry maggot is said to confine its work to the sweet and sub-acid varieties, but its new American congener seems to be less particular in its tastes. The Massachusetts parties who first called our attention to the insect write us that "all our cherries were badly infested, the Downer and the black ones, but the Morellos were the worst." At Ithaca, N. Y., only the early varieties are reported infested; while at Geneva, N. Y., the insect confined its work this year mostly to the English Morello and the Montmorency varieties, the latter being the worst infested. It thus seems that the pest may attack all varieties of cherries whether sweet, sub-acid, or sour, or whether early or late; the Morello and Montmorency varieties seem to have suffered the most this year.

IT MAY ATTACK PLUMS OR PRUNES.

One grower at Geneva, N. Y., reports that he fears the same insect worked in his prunes last year. Ten years ago maggots were found working in both cherries and plums in Northern Michigan. These were thought to have been the apple maggot, but we believe they were identical with those which have worked in the cherries of New York and Massachusetts this year. Our correspondents report that thus far this year they have found no indications of the maggots in their plums or prunes. It would not be surprising to find the maggots working in these fruits, which are oftentimes grown nearby, as they are not very dissimilar in their nature to the cherry. Thus growers of plums and prunes, as well as of cherries, should familiarize themselves with this serious menace to their business. Should anyone find maggots or "worms" of any kind in plums or prunes, we would like to be notified of the fact at once.

ITS DISTRIBUTION AND DESTRUCTIVENESS.

We have evidence of the work of this new cherry pest this year from Belmont, Mass., and Ithaca and Geneva, N. Y. The fly which we found on the fruit at Geneva, and which we feel quite sure is the adult insect, is recorded from the Middle States only. It was doubtless the same insect which worked in Northern Michigan ten years ago, as noted above. Thus cherry growers in the Eastern, Middle and Northern States should be on the lookout for the pest.

At Belmont, Mass., about one-third of a six or seven-ton crop of cherries were ruined by the maggots this year. The pest also destroyed from one-fourth to one-third of the crop of English Morello and Montmorency cherries in one orchard at Geneva, N. Y. These facts show that the new pest will become a serious menace to cherry growing in certain sections. Another serious phase of the matter is the fact that the presence of the pest may not be known until the fruit gets into the hands of the consumers, and such fruit will not help in making future sales to the same parties.

ITS HISTORY, IDENTITY AND NAME.

So far as we can find there are recorded but two earlier instances where maggots have been found in cherries in America.* For more than a century European cherry growers have suffered from the ravages of a maggot in the fruit. The first record we find of maggots in cherries in America was made by Dr. Hagen, of Cambridge, Mass., in 1883. That year maggots were very common in the fruit of a black cherry tree imported fron Prussia and set in his garden ten years before. He found no differences between his maggots and pupæ and those of the European cherry maggot, but stated that this was not sufficient evidence to prove the specific identity of the two cherry pests. He expected to raise the adult insect and thus settle the identity of our American cherry maggot, but evidently he did not rear the fly, as we are informed that no flies or even any of the maggots are to be found in the collections at Cambridge. It is an interesting fact that we received our first intimation of the existence of such a pest from Belmont, Mass., which is only a few miles from where Dr. Hagen found cherry maggots in 1883.

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*Although the bibliography appended to this bulletin includes several references to cherries being found infested by maggots, it may be noted that the records of Cook, Cordley and Davis all refer to the same case of infestation.

In 1889, specimens of cherries and plums badly infested with maggots were received at the Michigan Experiment Station from northern Michigan. Brief notices of this infestation were soon published (see bibliography) by Cook, Cordley and Davis. Cordley stated that "from the accounts of our correspondents describing the attack, and from a close examination of both the larva and pupal stages of the insects received, the cherries and plums seem to be badly infested with *Trypeta pomonella* (the apple maggot). Whether these are the descendants of small Trypetas which had formerly acquired a taste for apples, or whether certain individuals of those feeding upon the hawthorn have 'dropped their plebeian tastes and adopted a more refined table regimen,' it is unsafe to say, but from the fact that the apple maggot has never been known to attack the apple of northern Michigan, and from the fact that while the apple maggot is abundant on hawthorn everywhere in Michigan, and as it has not attacked the cherries nor plums elsewhere, it seems probable that a cherry and plum loving race of the apple maggot has developed or is being developed in northern Mchigan, directly from those which fed upon the hawthorn." Unfortunately none of the adult insects seem to have been bred, and we are informed that even none of the maggots are to be found in the Michigan College collection.

Some of the Geneva cherry growers noticed a few maggots in their cherries last year, and we are informed that they have been seen at Ithaca for a year or more, while our afflicted correspondent at Belmont, Mass., reports that they think their fruit has been infested for the last four or five years, but not nearly so bad as this year.

While there seems to be no evidence extant to ever enable one to determine just what insect is responsible for these two earlier records of maggots in cherries, yet we think the cherry maggots we received this year are the same as those previously recorded. And we furthermore seriously doubt if this new cherry pest is the same as the common apple maggot (*Rhagoletis pomonella*) in spite of the fact that we, like Cordley, have been unable to distinguish between the maggots found in cherries and those working in apple.

The facts recorded by Cordley, as quoted above, strongly indicate that the cherry maggot is a different and distinct insect, and we submit the following evidence in support of this theory. On August 4th we visited an infested orchard at Geneva, N. Y., and found quite a number of English Morello cherries still on the trees, and one or two trees bore many fruits of what the owner called a "sport" or reversion from the English Morello. Many of the fruits contained the maggots, and we soon saw many of the little flies shown in figure 12, on the trees, *almost always on the fruits*. Several of the flies were captured and found to be a species described in 1862 as *Rhagoletis cingulata*, from the Middle States. This fly is thus a very near relative of the apple maggot (*Rhagoletis pomonella*), and a still more significant point is the fact that Loew, in his original description of the fly we found on the cherries, says it is closely allied to the fly of the European cherry maggot. As Doane (1898) has recorded, six species (one, *zephyria*, may prove to be a synonym) of flies of the genus *Rhagoletis* have been described from the United States. The habits are known of only two of these flies, (*R. pomonella*, the apple maggot, and *R. ribicola*, the dark currant fly) and the maggots of these live in fruits.

As we saw no similar flies on the cherry trees, as we found *Rhagoletis cingulata on the fruits*, in considerable numbers, and in view of the facts just submitted regarding the relationships and probable fruit-feeding habits of this fly, it is easy to understand why we have been lead to think that the fly in figure 12 is the adult of our American cherry maggot, and that, therefore, this maggot is a distinct species from the apple maggot. When the adult insects emerge in our breeding cages next spring, our theory, outlined above, may be demolished, as we may get apple maggot flies or something else entirely unexpected, but this will not materially affect the purpose of this bulletin to record all we have been able to glean regarding an insect, whether old or new, which may certainly be classed as a *new cherry pest.*

For this new cherry pest we would propose the popular name of *the Cherry Fruit-fly.* We prefer this name to *the Cherry Maggot* as it is more expressive of the insect's habits, and similar fruit inhabiting maggots in other countries are known as *Fruit-flies.*

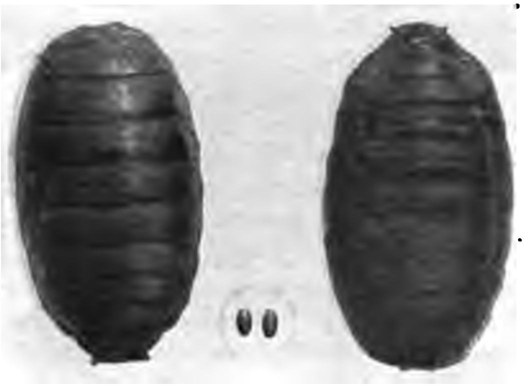
POSSIBLE NATURAL FOOD-PLANTS OF THE INSECT.

If this cherry fruit-fly turns out to be the well-known apple-maggot fly, then, of course, its native or original food-plant is the hawthorn. But if this new cherry pest is *Rhagoletis cingulata*, or some insect other than the apple maggot, then we must look to the native species of wild cherries, or possibly wild plums, and also to the species of *Berberis* and *Lonicera* for its natural food-plants. The latter plants are mentioned as possible native food-plants of the American cherry fruit-fly because the European cherry fruit-fly is known to breed in several species of *Berberis* and *Lonicera.*

THE STORY OF ITS LIFE.

Having first made the acquaintance of this new cherry pest only about two months ago, we have had, therefore, no opportunity to follow it through its yearly life-cycle. Hence we are unable to tell the story of its life in detail.

How it spends the winter.—The insect doubtless spends the winter in the soil, usually not more than an inch below the surface, in the condition shown, natural size and much enlarged, in figure 15. It is a dark brown, lifeless-looking object known as a *puparium*. Within this hard, stiff, brown shell, which is really the contracted and hardened skin of the maggot, the insect changes from a maggot to a *pupa*. Whether the pupa is formed before spring, we cannot yet say.



15.—*Dorsal and ventral views of the puparia of the cherry fruit-fly. Natural size and enlarged.*

Emergence in the spring.—During the spring months the transformation from a pupa to the adult insect—the pretty little fly shown in figure 12—takes place. When the time for emergence comes, the little fly bursts open one end of the puparium (figure 15,) crawls out, works its way up through the inch or less of soil, and then flits away to find its mate and the food-plant for its progeny. As to when these cherry fruit-flies emerge in the spring we have no evidence. The yellow currant fruit-fly (*Epochra canadensis*) sometimes emerges in May, but the nearer relatives of the cherry fruit-fly, the dark fruit-fly (*Rhagoletis ribicola*) and the apple maggot fly (*Rhagoletis pomonella*) may emerge about the middle of June in the latitude of New York. Hence, we would infer from this that the cherry fruit-fly may be expected to emerge about June 15th, in New York. The date of appearance of the flies on the trees will doubtless vary somewhat with the latitude and the season. The flies will doubtless continue to emerge over a considerable period, perhaps a month or more ; the flies which we suspect are the adults of this pest were found on the fruit as late as August 4th.

Egg-laying.—We have not seen the fly lay an egg, but think we have found its eggs in the cherries. We found many minute punctures through the skin of the fruits, and obliquely just beneath the skin in the flesh we could discern the remains of a hatched egg. In a few cases we found an unhatched egg, but always crushed it before we could disengage it from the flesh of the fruit. Hence, we are unable to describe or picture the egg. We feel quite sure, however, that the mother fly punctures the skin of the fruit with her ovipositor and then inserts obliquely an elongate, whitish egg in the flesh just beneath the skin. Mr. Lowe has recorded the following observations regarding the egg : " Egg-laying undoubtedly begins as soon as the first fruit ripens, as young maggots were found in some of the earliest fruits. It continues as late as the middle of August, and probably later. We have found young maggots as late as August 16th. On the same day an unhatched egg was found. The eggs are placed nearly or quite under the skin. One egg was found on the outside. A single egg measured 5 mm. (.02 inch), somewhat broader toward one end, and about one-fourth as wide as long, at the widest point. Beginning at the broad end and extending about one-fourth the length of the egg, the shell is roughened and somewhat darker ; color, a dirty yellow." The flesh of the fruit seems to slightly thicken or harden around the egg and adhere closely to it. Apparently the eggs are laid in any part of the fruit. Old egg-scars are quite easily discernable on the cherries ; the minute, round depressed spot on the right-hand cherry of the two upper ones in figure 13 is probably an egg-scar.

Egg-laying doubtless extends over a considerable period, probably beginning in June and continuing until into August, if any cherries remain on the trees so long. We have no data bearing on the duration of the egg-stage. The eggs probably hatch in a few days.

The maggot's life.—As the eggs are laid beneath the skin, the moment it hatches, the maggot finds itself surrounded with its favorite food, the juicy flesh of the fruit. It apparently soon makes its way to near the pit where it proceeds to revel in the flesh, soon forming a rotting cavity, as shown in figure 14. The maggot spends its whole life of three or four weeks in a single cherry, and rarely more than one maggot is to be found in the same fruit. Apparently many of the maggots are nearly full grown about the time the fruit is ready to pick, and they find their way into the consumer's hands. Afflicted orchardists report that but few of the infested cherries fall from the trees, hence when the maggots emerge they doubtless drop to the ground, where they soon bury themselves just beneath the surface. Very soon after entering the ground, probably within a day or two, the maggots contract, their skin hardens and turns brown, and the *puparium* stage is formed. The maggots will change to puparia in any convenient place, as the bottom of baskets, rubbish, etc.

Number of broods.—We have some puparia which were formed in our breeding cages as early as July 11th, from which no flies have yet emerged. Hence we conclude that the insect winters as a puparium, and furthermore, that there is but a single brood of this new cherry pest in a year. Evidently the insect may spend ten or even eleven months of its life in the soil in the *puparia* stage.

HOW THE INSECT MAY BE SPREAD.

As it infests only the fruit, one need have little or no fear of receiving this new cherry pest from nurserymen. If nursery trees happen to be grown under infested cherry trees, it is possible that a few puparia of the pest might be carried away in the soil adhering to the roots of the nursery stock.

As many of the maggots emerge from the fruits, after they reach the consumer's hand, the insect may thus obtain a foothold in new localities. It is quite possible that the insect may be more readily and widely spread in this manner than in any other.

Doubtless the pest will spread quite slowly from tree to tree and thus from orchard to orchard, as the adult insects are slow in their movements and are not long-fliers. This is a very important fact for it makes *the checking of this new cherry pest largely an individual matter, to be worked out independently by each cherry-grower.*

DISCUSSION OF REMEDIAL MEASURES.

It is to be hoped that this new cherry pest is not widely distributed, or that it will never become a serious factor in cherry growing, because it will prove a very difficult pest to control. We have not had time to test any remedial measures, hence can only suggest possible methods, drawn from our experience in combating other insects, from what we know of the habits of the insect, but more especially from the experience of fruit-growers in Australia, South Africa and Europe, where similar fruit-flies are serious drawbacks to fruit-growing.

Apparently there is no possible chance of getting at the insect with a spray of any kind while it is in the egg, in the maggot, or in the puparium stages. The egg is out of reach beneath the skin, in the flesh; the maggot spends practically all its life inside the fruit, only a day or two is spent in getting from the fruit into the soil and changing into a puparium; and this puparium would doubtless be impervious to any liquid applied to the soil in such quantities as not to spoil the soil or injure the tree.

If the maggots caused the infested cherries to fall prematurely, or so affected them as to render it easy to discover which fruits were infested, then one could do much toward controlling the pest by removing such fruits from the trees or by picking up the "windfalls" and destroying them. This latter method can be successfully employed against the apple maggot, which does cause the apples to drop prematurely and which rarely, if ever, leaves the fruit until it does fall or is picked. But afflicted cherry growers state that but few, if any, infested cherries fall prematurely, and also that there is no way of distinguishing the infested cherries from the others at picking time.

Hence there seems to be no practicable method of getting at the pest while it is in the fruit, except the heroic method of picking and destroying by boiling, burying, or otherwise, the whole crop on the infested trees just about the time the first fruits are ready to pick, or even before. This method, of course, involves the loss of the cherry crop for a season, but it is the only sure method we can conceive of to completely check the pest. Usually certain trees or certain varieties will become infested first, and the destruction of the crop on these few trees would not count for much as against their being a constant source of danger to the rest of the orchard. The pest could be quickly stamped out in this way and as it spreads very slowly, it might be a long time in again getting a foothold in the orchard. This method of destroying the crop of cherries for a season, while it is an heroic one, it yet deserves to receive the serious consideration of cherry growers who may be unfortunate enough to have this cherry fruit-fly to combat.

As the insect spends ten months or more of its life in the soil, usually less than an inch below the surface, it would seem as though some method might be devised to check it then. All of this time is spent in the pupariam stage (figure 15), and as we have stated above, while in this form the insect would not be readily affected by insecticides of any sort. We doubt if any of the puparia could be killed by the application of any reasonable or practicable amount of any insecticide, especially such substances as the commercial fertilizers, gas lime, lime or salt. Gas lime has been tried in Australia with no success.

As the puparia are so near the surface of the soil from July until the following June, it would seem as if thorough cultivation might be successfully employed against the pest. But it is evident that the usual methods of cultivation employed by our most successful orchardists has little or no affect on the pest, for those who suffered from it this year were good, thorough cultivators. A possible explanation lies in the fact that the puparia are too small to be crushed, and they are so near the surface that the usual shallow cultivation of the orchard does not materially change their position relative to the surface. Possibly deep plowing, which is not often practicable in a cherry orchard, in late fall or early spring, might bury these puparia so deeply that the emerging flies could not get to the surface. Where only a few trees were infested it would be practicable to remove the surface soil to a depth of an inch or so from beneath the tree and either bury it deeply, put in the hen yard, or in a much-traveled roadway.

One afflicted cherry grower sends the following valuable hint. "We have growing in our hen-yard several cherry trees, and they were not as badly infested as the trees outside of it. We can only account for it in that the hens found the insects as food." Undoubtedly hens would find many of the brown puparia in the soil, and could doubtless be successfully employed against the pest on a few trees. Place a temporary wire-netting fence around one or more trees, turn the hens loose in the enclosure, and stir the soil every day or two to encourage them. Do this soon after the fruit is picked and we doubt if many of the puparia will escape the sharp eyes of the fowls.

Something can be done toward checking the pest by not allowing any cherries to remain on the trees after the last picking. If what few " windfalls " there might be were destroyed, all the marketable fruit picked and disposed of, and all fruits removed from the tree at the last picking, most of the infested cherries would be gotten out of the orchard before most of the maggots had matured and gotten into the soil Of course, where early and late varieties are infested in the same orchard, this plan might not noticeably diminish the numbers of the pest. It is well worthy of consideration, however.

There yet remains one stage of the insect against which we have not turned our destructive batteries. One of the first questions asked us by an afflicted cherry grower, when he understood how little chance there was of getting at the insect while in the fruit or in the soil, was, why cannot we either kill the flies, or deter or prevent them from laying their eggs in the cherries. He inquired if bad-smelling substances hung in the trees or sprayed upon them would not drive the flies away. Apparently no experiments along this line have been made in this country against similar flies, but, fortunately our Australian and South African fruit-growers, who are sorely afflicted with fruit-flies, have recently carried on valuable and instructive experiments against the flies. The following summary of their experiments and conclusions cannot fail to be of value and interest to our American cherry-growers.

The flies are not attracted to lights in Australia, so that trap-lanterns will be of no avail against the pest.

Messrs. Benson and Voller made a careful and extensive series of experiments in the orchards of Queensland, Australia last year. The objects of their experiments were to prevent or deter the flies from attacking the fruit, and to attract and destroy the flies.

In the first series of experiments they sprayed the fruit and trees with strong smelling substances that were deemed likely to deter or repel the fly. They sprayed with sulphide of lime, sulphide of soda, lime, sulphur, wood tar, bone oil, caustic soda, carbonate of soda, whale-oil soap, tobacco, pyrthum, black leaf tobacco extract, nicotine, and Redwood's specific. Most of the substances were used singly and in various combinations. None of the mixtures injured the fruit or trees to any extent. Many of the mixtures had a very strong and persistent smell, which was retained on the trees and fruit for at least a week after application, and the smell was not washed out by rain, but rather intensified for the time.

Balls of cotton waste saturated with bone oil and other strong smelling substances were also hung in various trees to determine if the odor will deter the flies or not. Flies were seen on fruit within a few inches of the cotton waste, and the trees so treated were as badly infested as any untreated ones.

No spray that was tried was a complete success, even though numerous applications were made; but some mixtures* seemed to keep the flies from the fruit for a certain time after their application, as in the case of the same varieties of fruits, on trees that were sprayed, they were unable to detect a single fly laying eggs, whereas the flies were numerous and busy on adjacent trees. No spray, however, was lasting, as where the applications were made from a week to ten days apart, part of the fruit was infested, but not to the same extent as on untreated trees, thus showing that the applications must be frequent during the ripening of the fruit to be of any avail.

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* *Mixture A*:—Boil two pounds of sulphur and one pound of 98 per cent. caustic soda in two gallons of water till the sulphur is dissolved, and a mixture known as sulphide of soda is formed. Add six pounds of whale-oil soap, 80 per cent.; and boil for half an hour, adding boiling water to make five gallons of mixture; and add forty fluid ounces of black leaf tobacco extract. Next add water to make forty gallons, and it is ready for use.

Mixture B:—Dissolve one pound of whale-oil soap, 80 per cent., in four gallons of boiling water. When dissolved, add twenty-five fluid ounces of bone oil and mix well; add water to make forty gallons, and it is ready for use.

Mixture C:—Mix equal parts of A and B.

The experimenters record their belief that careful and frequent sprayings with the mixtures noted above will protect a considerable portion of the crop, but at the same time they are confident that to be of any value the spraying must be very carefully carried out, and must be backed up by destroying all infested fruit and taking every possible precaution to keep the insects in check.

In the second series of experiments made by Messrs. Benson and Voller they tried to attract, catch, or poison the flies. They record that they had no success whatever, as they failed to attract the flies. They used highly-scented sticky baits, highly-scented poisoned baits, and poisoned fruit baits; but, though numerous insects of various kinds were caught or destroyed, the fruit-flies escaped. The experimenters could not find that the flies fed on anything, as, with the exception of seeing them occasionally apparently sucking the juice exuding from a puncture they had made in a fruit, they were never seen to be attracted by or feeding on anything.

In South Africa the only effectual method of preventing the fruit from attacks by these fruit-flies thus far devised is to enclose the trees in a fine-meshed mosquito netting during the time when the flies are about.

We may thus glean from the above summary of the results attained in other countries in combating similar fruit-flies, that there is but little hope of successfully combating our American cherry fruit-fly in the adult or fly state.

No careful experiments seem to have been made in Europe against the European cherry fruit-fly, and the recommendations made for combating the pest are few, usually theoretical, and add nothing new to what we have already suggested, with one exception, which may be of interest to housewives and eaters of the luscious fresh fruit. One German writer states that "it is known to those housewives who wish to can cherries that the maggots leave the fruits as soon as they have been soaked in water for several hours; and this precaution can therefore be taken with the cherries to be eaten fresh in those years when the cherries are badly infested." We wish the author of this suggestion had been a little more definite, for we are in some doubt as to what is to be done with those fruits from which the maggots have emerged. Are they to be canned or eaten with the rest.

MARK VERNON SLINGERLAND.

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The following are also included in this bibliography, as we believe they refer to this cherry fruit-fly. They are the only records known to us of the occurrence of fruit-fly maggots in cherries in the American literature.

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1889. Cook. 2d Ann. Rept. Mich. Expt. Station, p. 153. Records receiving plums and cherries from northern Michigan supposedly infested by Apple Maggot.

Cordley. Orchard and Garden, Oct., 1889, p. 192. Records closely examining larvæ and pupæ of plum and cherry maggots from northern Mich. with the result that they seemed to be those of *T. pomonella*. Says *pomonella* has not been known to attack apples in northern Mich., but does occur in haws. Cherry and plums were badly infested.

Davis. *The Ohio Farmer*, Nov. 9, 1889. Records practically same facts as Cordley (1889).

1890. Harvey. Ann. Rept. of Maine Expt. Station for 1889, pp. 192, 233, 234, 235. Records Cook's, Cordley's and Davis' observations and suggests that their plum and cherry maggots may be a distinct species from the Apple Maggot.

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Bulletin 173. **November, 1899.**

Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

DAIRY DIVISION.

The Relation of Food to Milk-Fat.

DAIRY BUILDING.

By LEROY ANDERSON.

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THE RELATION OF FOOD TO MILK-FAT.

Can the per cent of fat in milk be increased through changes in the food of the cows? This is a question about which there has been more debate and which has been the subject of more experimentation than any other problem relating to the production of milk. Some experiments have seemed to indicate that certain foods possess the power of increasing the proportion of fat in milk, while others, and much the larger number, show that the variations in the quality of milk are not traceable to the food. All who are familiar with the handling of milk know that variations in the per cent of fat do exist and this with the same cow on the same feed and under uniform environment. Why the quality of milk fluctuates so widely under conditions which to all outward appearances are the same, has never been determined experimentally. The secretion of milk is so intricate and its processes so completely hidden from view that a clear understanding of them seems quite impossible. Nevertheless all careful experiments conducted with a view to solve the problem are valuable even though only negative results be obtained and although the conclusions reached may be more or less conjecture.

Experiments conducted for the purpose of determining the relation of food to milk production have usually shown that where a sudden and radical change in the food has taken place, this change has been accompanied by a more than ordinary variation in the per cent of fat. This variation may be either an increase or a decrease. After the cows become accustomed to the new feed their milk returns to its former average per cent of fat, which may be called the normal per cent. Such phenomena would seem to indicate that the per cent of fat in milk is subject to the peculiar constitution of the cow and that she will give milk of a certain average composition so long as nothing occurs to disturb the "even tenor of her way."

A definite knowledge of the relation of food to milk-fat would solve the question as to whether or not the per cent of fat may be permanently increased by feeding. But concerning this point we have little information except theories based upon the results of many experiments. One theory has been long and largely held that milk-fat is produced from the protein in the food. If this were the case a natural supposition would be that by increasing the amount of protein in the food, the proportion of fat in the milk would be thereby increased. Another theory is that milk-fat is produced from the fat in the food. Then feeding an increased amount of fat might be supposed to result in a higher per cent of fat in the milk; or, on the other hand, a decrease in the supply of food-fat would likewise cause a decrease in the per cent of milk-fat. A third theory, and the one which is most largely entertained, is that so long as the animal is well nourished the per cent of fat in the milk is not appreciably affected by even wide variations in the character of the food. Experiments supporting these three theories will be found in subsequent pages.

The question has a practical bearing in the economical management of the dairy. For, if by food we may increase the richness of the milk, then there is opportunity to enhance the value of all our cows. Butter-fat is the most valuable constituent of milk, and if the cow may be made to produce a milk richer in fat by giving her certain foods, or foods containing a large proportion of a particular nutrient, then the dairyman may increase the value of his cows to the extent that they may be made to respond to the particular foods by increased production of fat. In general this has not been found to be the case, otherwise why should so many cows be giving milk that is comparatively poor in fat? And why should they possess this same characteristic in common with their ancestors as long ago as their history is known to man.

Again, if feeding large amounts of protein tends to an increased production of milk-fat, then the dairyman will need to purchase foods containing a high proportion of protein, which foods usually command higher prices than those containing less protein. If, on the other hand, a large supply of protein is not essential to the production of milk-fat; if the per cent of milk-fat is dependent on the supply of food-fat; or, if it is not governed by the food so long as the cow is well nourished, then the dairyman is warranted in feeding those cheaper foods which contain less protein and more carbohydrates and fat.

A conclusive answer to the question asked at the beginning is not attempted in this bulletin. The record is given of two long experiments with rations having different nutritive ratios, and also a less extended one with a ration containing varying quantities of palm nut meal. Considerable space is given to a summary of the leading experiments relating to the influence of food on milk production with especial reference to the quality of the milk by which is meant here its percentage of fat.

The records of these experiments are gleaned from all reliable sources both domestic and foreign. The object is to place before the general farmer and reader a knowledge of what has been done to solve the mooted question of "feeding fat into milk" by experimenters abroad as well as at home. In collecting this data free use has been made of all experimental literature obtainable and reference is usually made to the original article. The Experiment Station Record has been used freely, especially for translations of foreign experiments which are reported in periodicals not found in our own library. The attempt has been to make this summary as brief as possible and yet give a fair idea of the plan and scope of the experiment, together with the results or conclusions obtained.

SUMMARY OF EXPERIMENTS CONCERNING THE RELATION OF FOOD TO THE PERCENTAGE OF FAT IN MILK.

Jordan* experimented on five cows with three different kinds of rations during three periods, the rations being made up so as to contain varying amounts of vegetable fats, and found that the yield of milk diminished somewhat in passing from the ration rich in fat to the one containing less fat, and increased slightly after changing again to the fat rich ration. "The composition of the milk varied but little and no more, or even less, during the three periods than is often observed when the ration is not changed."

In a later experiment† Jordan fed three cows during three periods of 35 days each on two rations, one having a nutritive ratio of 1:6.7 and the other 1:12.3 and found that "the yield of milk from the nitrogenous ration was from one-fifth to more than one-third larger than that from the carbonaceous ration. In general the milk was materially richer while the cows were fed the ration rich in protein. * * The composition of the milk solids seemed to be independent of the ration. In general the proportion of fat increased throughout the experiment without regard to what the cows were fed, and no evidence is furnished in support of the notion that by changing the food it is possible to produce more butter-fat without an accompanying increased production of the other milk solids."

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* Maine Station Annual Report, 1891, p. 62.

† Same, 1893, p. 73.

Whitcher,* after studying the effect of pasture and silage, and of changing the nutritive ratio on the quality of the milk, found very little variation in the per cent of fat and concludes: "I feel warranted in saying that a given animal by heredity is so constituted that she will give a milk of certain average composition; by judicious or injudicious feeding the amount of milk may be largely varied, but the quality of the product will be chiefly determined by the individuality of the cow."

Wood,† in experimenting on the effect of some coarse fodders on quantity and quality of milk during several experimental periods of two weeks each, found "no variation in the quality of the milk that could be attributed to the character of the food."

Later,‡ he fed three cows for two weeks on a basal ration of silage, clover hay, vetch hay, oats and middlings. Then in three subsequent periods of two weeks each, palm oil, cotton-seed oil, corn oil, oleo oil, cocoanut oil and stearin were fed to different cows at the rate of 12 ounces per 1000 pounds live weight, making a nutritive ratio of 1:6.8. The conclusions reached were: "That the first effect of an increase of fat in a cow's ration is to increase the per cent of fat in her milk."

"That with the continuance of such a ration the tendency is for the milk to return to its normal condition."

"That the increase in fat is not due to the oils but to the unnatural character of the ration."

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*New Hampshire Station Bulletin 9, 1890.

†New Hampshire Station, Bulletin 18, 1892.

‡Same, Bulletin 20, 1894.

"That the results of this experiment tend to confirm the conclusions expressed in previous bulletins from this Station; that the composition of a cows' milk is determined by the individuality of the cow, and that although an unusual food may disturb for a time the composition of the milk, its effect is not continuous."

Hills* studied the effect of heavy feeding of grains on milk production by giving two cows for two months a continually increasing amount of grain until they were receiving all they would eat. He found that there was little change in the composition of the milk on increasingly heavy grain feeding, and that no connection could be traced between the quality of the milk and the food given.

Again,† in a series of feeding tests covering five periods of four weeks each, and using thirty-one cows, he experimented with various coarse fodders, grains and mixed feeds. The invariable conclusion was that there was no material change in the quality of the milk as a result of the change in ration.

Cooke‡ in reporting an experiment in feeding sugar meal, cream gluten meal, and germ meal to nine cows for four months in periods of four weeks each, says: "We are led to the conclusion that sugar meal and cream gluten have a slight effect toward an increase in the richness of the milk."

Lindsey§ fed six cows in nine and fourteen-day periods with seven days preliminary feeding to each period on rations containing amounts of protein which varied from 1.3 to 3.76 pounds per head daily, and the nutritive ratio varied from 1:4.4 to 1:10. The periods were rather short, but the "indications are that the composition of the milk, especially the fat, appeared to be favorably affected by the addition of protein up to three pounds, although there was considerable difference in the cows in this respect."

Lindsey, Holland and Billings‖ varied the nutritive ratio of the ration from 1:3.86 to 1:9.43 while feeding six cows in two lots of three each, during four periods of 21 to 26 days each, with a seven-day preliminary period. They conclude:

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*Vermont Station, Annual Report, 1890, p. 75.

†Same, 1895, p. 203.

‡Vermont Station, Bulletin 31, 1892.

§Massachusetts (State) Station Annual Report, 1894, p. 42.

‖Massachusetts (Hatch) Station, Annual Report, 1896, p. 100.

"That the same amount of digestible matter in the narrow rations produced from 11.8 to 12.9 per cent more milk than did a like amount of digestible matter in the wide rations, and that neither the narrow nor wide rations produced any decided change in the composition of the milk.

Jordan and Jentner* changed the ration of a cow in three ways: "(1) By decreasing the fat in the food from about the usual quantity to practically none; (2) by producing wide variations in the protein supply and nutritive ratio, and (3) by producing wide variations in the supply of total digestible material." The cow was "fed during ninety-five days on a ration from which the fats had been nearly all extracted, and she continued to secrete milk similar to that produced when fed on the same kinds of hay and grain in their normal condition." The food-fat eaten during this time was 11.6 pounds, 5.7 pounds of which was digested, while the yield of milk-fat was 62.9 pounds. Throughout the whole experiment, "the composition of the milk bore no definite relation to the amount and kind of food."

Wing† added ordinary beef tallow to the usual grain ration of ten cows, giving them at first four ounces per head, and increasing the amount gradually until each cow was consuming two pounds daily, which amount was fed for six or seven weeks. He found "no increase in the per cent of fat in the milk as a result of feeding tallow in addition to a liberal grain ration."

Waters and Hess‡ gave rations varying in nutritive ratio from 1:3.9 to 1:6.65 to nine cows through four periods of thirty days each, and say: "It appears that the narrower nutritive ratio tended to increase the per cent of fat."

Farrington§ studied the effect of heavy grain feeding by giving three cows from December 1 to June 1, in eight periods ranging from 6 to 51 days, an amount of grain increasing continually from 12 to 24 pounds per head daily where it was held for two months, when it was decreased gradually until the cows went to pasture, May 1.

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*New York (State) Station, Bulletin 132, 1897.

†New York (Cornell) Station, Bulletin 92, 1895.

‡Pennsylvania Station, Annual Report, 1895, p 56.

§Illinois Station, Bulletin 24, 1894.

The nutritive ratio varied from 1:4 to 1:9.4. He found "that the increase of feed was accompanied by a considerable increase in the pounds of milk produced, and consequently in the pounds of solids, fat, and solids not fat in the milk ; but with the exception of one or two days, there were no greater changes in the percentages of fat in the milk after the increase of feed than before it was made."

Wilson, Kent, Curtiss and Patrick* compared corn and cob meal with sugar meal by feeding them to four cows in alternating periods of 21 days each with a 10-day preliminary period, and conclude that "quality of milk, so far as measured by its percentage of fat, was changed by feed to a much greater degree than was quantity. Sugar meal produced 17 per cent more fat and six per cent more total solids per 100 pounds of milk than did the corn and cob meal."

Armsby,† during three periods of three weeks each with two cows compared bran with corn meal and found that while there were slight changes in the composition of the milk there was "no indication that the feeding had anything to do with these changes." Again in comparing in a similar manner bran with oil meal there were slight changes as before, but "we may safely conclude that whatever changes took place in the composition of the milk-solids were due to advancing lactation and not to the feed."

Woll‡ in comparing the feeding value of ground oats and bran for milk production, found that "the cows invariably did better on oats, going up in milk yield when coming on oats and going down when bran was fed, while the fat content of the milk remained the same on an average."

Linfield§ studied the effect of two rations varying in nutritive ratio on the per cent of fat in milk with ten cows during eight periods of three weeks each. He concludes, "this test adds but another item to the fairly well established fact that an increase in the quantity of concentrated food in the ration of a cow, does not increase the richness of the milk provided the cows are well fed to start with."

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*Iowa Station Bulletin 14, 1891.

†Wisconsin Station Annual Report 1886, pp. 115 and 130.

‡Wisconsin Station Annual Report 1890, p. 65.

§Utah Station, Bulletin 43, 1895.

Dean* carried on experiments during several years to ascertain the effect of food on the quality and quantity of milk. The results obtained from feeding coarse fodder with and without grain, from comparing pasturage with and without grain, from feeding slop, and from other experiments, generally agree with this statement made in Bulletin No. 80, that "the general conclusion would seem to be that the food does not affect the quality of the milk to any appreciable extent so long as the animals are in good condition."

Speir† reports at least three different experiments on the effect of foods on milk production. He tested a large number of different kinds of feeding stuffs both singly and in various combinations during periods of four to five weeks in length. Some of his conclusions are that "an increase of oil in the food does not seem to give any increase of fat in the milk. Rations having an extremely high albuminoid ratio seem to have a depressing effect on the milk yield, well mixed foods giving the best results in this respect. Every food when first given, seems to have more or less effect in increasing or decreasing the percentage of fat in the milk. This effect, however, is transitory and the milk returns to its normal composition about the end of the fifth week."

Stohmann,‡ in experimenting with goats found that the fat content of the milk was proportional to the fat content of the fodder, but that by a great increase in the nitrogenous foods, the milk-fat did not increase in the same way as when the fat content of the food was increased.

Kühn§ carried on extensive feeding trials with bean meal, palm nut cake and malt sprouts, having in all 42 experiments with 10 cows. The feeding periods varied from 21 to 47 days in length. The grains were fed separately in addition to a normal ration and in quantities of 1.5, 2 and 3 kilograms* per head daily. According to his results the fat content of the milk increased proportionately with the increase of protein fed, but did not decrease in the same proportion when the protein in the food was decreased. He concludes "that the palm nut cake exerted on the whole a favorable influence upon milk production and especially upon the fat content of the milk." The bean meal and malt sprouts did not have a like favorable effect. He found that the addition of one-half kilogram of oil to the ration increased the quantity and quality of the milk. But he considered "that this added fat had no *direct* influence on milk production; that it has an indirect effect in this manner: that a certain quantity of protein is thereby made available for milk production which before the feeding of the fat was used in sustaining the animal body, but the fat now performs this office and permits the protein to be used for producing milk." He concludes also "that these experiments, according to all observations, prove in the clearest manner how greatly the milk production, and the possibility of influencing arbitrarily through feeding the amount or composition of the product, are dependent upon the individuality of the animal."

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*Ontario Agricultural College and Farm Report 1891, p. 154; 1893, p. 148; 1894, pp. 147 and 148.

†Transactions of the Highland and Agricultural Society, Scotland, 1894, p. 83; 1896, p. 269; 1897, p. 296.

‡Journal für Landwirtschaft, 1868, pp. 135, 307 and 420.

§Journal für Landwirtschaft 25 (1877), p. 332.

Heinrich† compared peanut cake with cocoanut cake, the latter ration containing 350 grams more fat than the former. The rations were alternated in periods of four weeks each and three cows were used. He found that the fat of the milk was considerably increased, both in percentage and total amount, when the cocoanut ration was fed, but there was much difference in the animals regarding this point. It is his opinion that the increased yield of fat may be accounted for by the increased amount of fat in the food.

Kochs and Ramm‡ fed three cows during four periods of about four weeks each, on rations which contained practically the same amounts of dry matter, and nearly equal amounts of digestible non-nitrogenous matter, but the amount of protein fed was such as to make the nutritive ratio vary from 1:8.19 to 1:5.42 to 1:4.31 and to 1:8.19 in the successive periods. They found that "the proportional fat content of the milk remained unchanged by the very wide changes in the food."

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*One kilogram (kg.)—2.2 pounds.

†Translation in Experiment Station Record Vol. 3 (1891), p. 67.

‡Landwirtschaftliche Jarhbücher 21 (1892) p. 809.

Klein* found that the addition of sunflower cake to the usual ration of four cows was followed by an increased milk yield, while it seemed to have no specific effect on the fat content of the milk.

Maercker and Morgen† report a series of coöperative experiments with farmers in which the effect of watery foods on milk secretion was studied. Beet diffusion residue (beet pulp) was fed alone and also with potato residue (from starch manufacture) in addition to a basal ration of hay, straw and grain. The amounts of residue fed daily were such as to give quantities of water ranging from 43 to 150 pounds per head. The experimental periods were ten days each. They found that the quantity of milk increased regularly with the increase of watery food up to 116 pounds, and that the increase in watery food was without discernible effect upon the composition of the milk.

Juretschke‡ has found as a result of the addition of 4 to 5 pounds, per thousand pounds live weight, of cotton seed cake, rape cake, and peanut cake to a basal ration consisting of hay, straw, brewers' grains and wheat bran, that the "milk secretion is not directly but only indirectly affected by feeding and that the feeding of large amounts of fat does not increase the amount of butter-fat in the milk."

Backhaus§ found by feeding ten cows on a basal ration of hay, straw, brewers' grains, etc. and alternating in periods of two weeks with peanut cake, palm nut cake and cotton-seed oil cake, that in order to bring about changes in the fat content of milk very little can be accomplished by the kind of food, and that the favorable effect of some concentrated foods which have been found to increase the fat takes place only when large quantities are fed.

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* Milch Zeitung 21 (1892) p. 673.

† Translation in Experiment Station Record, Vol. 3 (1892) p. 557.

‡ Molkerei Zeitung 7 (1893) p. 518.

§ Journal für Landwirtschaft 41 (1893) p. 328.

Soxhlet* reports some investigations on the production of milk richer in fat. He says nothing of the plan or extent of his experiments and gives nothing but the conclusions and a discussion of theories. As compared with hay alone, the addition of fourteen pounds of starch, treated with malt and given as a sweet drink, with sixteen pounds of hay made no appreciable increase in milk yield but a noticeable decrease (about 0.7 per cent) in fat. The fat content was practically the same when four pounds of rice gluten containing 71 per cent of protein was fed as when hay was fed alone. When sesame oil, linseed oil or tallow was added to the ration in the form of emulsions thoroughly mixed with the drinking water, the milk contained as high as 5.8 per cent of fat. When 1.5 to 2 pounds of linseed oil were added to 18 to 22 pounds of hay the milk averaged 5.24 per cent of fat for four days; when 1 to 2 pounds of tallow were added to the same amount of hay the milk contained from 4.24 to 5.5 per cent of fat, the average for eight days being 4.7 per cent. The author believes that the addition of oils to the ration in the form of emulsions will increase the per cent of fat in the milk while the addition of the same oils in other forms will not so increase it, because the oils are more easily digested in the form of emulsion. He does not believe that the fat of the food goes directly into the milk, but that it forces the body fat, *i. e.* tallow, over into the milk, and thus indirectly increases the quantity of milk-fat. He further states that the fat of the food alone, and not the protein or carbohydrates, is capable of bringing about a one-sided increase in the fat content of the milk.

Beglarian† studied the effect of linseed oil, given in water as an emulsion and of ground flaxseed with four cows during four periods of eight days each. The cows shrank in milk yield while taking the oil ration and increased on the flaxseed ration. The author considers the results entirely negative since the oil was not accompanied by an appreciable rise in the fat content, while it had an unfavorable effect on the digestion and comfort of the cows. The ground flaxseed had no effect on the quality of the milk and a less unfavorable influence on the animal's digestion.

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*Translation in Experiment Station Record, Vol. 8 (1897), p. 1016.

†Milch Zeitung 26 (1897) p. 522.

Holtsmark* found that feeding cows as much as 77 pounds of turnips per head daily in connection with a liberal ration of concentrated feed and cut straw, caused no decrease in the fat content of the herd milk, as compared with the feeding of the regular ration of hay, straw, concentrated feed and a small quantity of roots.

Ramm† to study the effect of different foods on milk production gave ten cows a basal ration consisting of 14 kg. of hay, 6 kg. straw and 50 kg. of beets, to which, for periods of ten days each, he added separately eighteen different foods. He found much variation in the fat content of the milk but no marked increase except with palm nut cake (7.91 kg.) alone and with a mixture of equal parts (8.25 kg.) of palm nut cake and beet molasses, this mixture being accompanied with a higher per cent of fat and total fat in the milk than any other food. For this reason the author thinks molasses has a greater effect on the quality of milk than palm nut cake. He found no relation between the fat content of the milk and the fat content of the food.

In a later experiment, Ramm made further comparison of the feeding value of various molasses mixtures. The mixtures used were peat molasses (80 per cent molasses and 20 per cent peat), liquid molasses, equal parts of molasses and palm nut meal, molasses pulp (molasses mixed with fresh potato pulp and dried), molasses chips (fresh beet pulp and molasses mixed and dried), barley meal and palm nut cake of average quality. The basal ration consisted of hay, straw and beets. There were seven experimental periods of 20 days each, the last five days only being used in comparison. Eight cows were used. He found the barley meal to excel the molasses preparations for milk production, but concludes that the latter induce an increase in the fat content of the milk.

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* Translation by F. W. Woll in Experiment Station Record, vol. 9 (1897) p. 92.

† Landwirtschaftliche Jahrbücher 26 (1897) pp. 693, 731.

Winternitz* fed a goat on sesame oil mixed with a small amount of iodin. He found a portion of the iodin was absorbed by the milk-fat and thus concludes that a direct transmission of the fat of the food into the milk may take place.

Albert and Maercker† studied the effect of rations rich and poor in fat, on ten cows during six periods ranging from 7 to 18 days, with preliminary periods ranging from 2 to 16 days in length. The amount of protein in the rations was kept constant while the fat was increased from .297 kilograms to 1.706 kilograms per head daily. They found that the feeding of such large amounts of fat increased the percentage of fat in the milk, but reduced the yield so much as to make such feeding unprofitable.

Kellner and Andrä‡ compared sugar beets with dried and ensiled beet diffusion residue by feeding them alternately to twenty-four cows during four periods of twenty days each. They found that ,, the substitution of 4.4 kg. of dried diffusion residue for 27.5 kg. of sugar beets increased the milk yield .953 kg. and the substitution of 41.8 kg. of ensiled diffusion residue for the above amount of sugar beets increased the milk yield 1.721 kg. per cow (of 550 kg. live weight) without causing any material change in the quality of the milk."

Friis§ reviews the co-operative cow feeding experiments conducted by the Experiment Station at Copenhagen, Denmark since 1888, with especial reference to the effect of food on the fat content of the milk. The summary of 76 series of experiments is given. The rations used were such as could be regarded normal for milch cows, such as are met with in the feeding practice on Danish dairy farms. The question whether abnormal feed mixtures can appreciably change the fat content of milk was not included in the investigation. The author says "it was found that different feeding stuffs and food mixtures in a very large measure influence the quantity of milk yielded as well as the health and general condition of the cows. The feed under practical conditions as found in this country, exerts an entirely insignificant influence on the fat content of the milk.

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* Zeitschrift Physiol. Chem. 24 (1898) p. 425.

† Landwirtchaftliche Jahrbücher 27 (1898) p. 188.

‡ Landwirtschaftliche Versuchs Stationen 49 (1898) p. 402.

§ Translation by F. W. Woll in Experiment Station Record Vol. 10 (1898) p. 86.

Rhodin* emulsified linseed oil in a specially constructed machine and fed from 250 to 750 grams of the emulsion daily as a drink in water to each of two cows during seven-day periods in addition to a normal mixed ration. During the first periods of feeding the oil, the fat content of the milk was increased, but during the third period the per cent of fat not only ceased to increase, but fell back to the same point as before the oil was fed.

Ramm and Winthrop † made a comparison of some new feeding stuffs using five cows for six months. The foods were corn bran, cocoa-molasses (hot molasses and finely ground cocoa shells), blood molasses (blood, molasses and refuse of cereals) and molasses distillery refuse (residue from manufacture of alcohol from beet molasses). They found a wide fluctuation in the fat content of the milk during different periods and believe that the molasses increased the fat content wherever it was fed, while the corn bran seemed to reduce the fat content. When feeding rations rich in fat they could see no relation between the fat content of the ration and the fat content of the milk.

Hagemann ‡ conducted some experiments to determine whether a fat rich fodder produces a fat rich milk. During five periods, varying in length from 21 to 35 days, he fed two cows on rations containing from 175 to 720 grams of fat. In addition to a basal ration the grains added were corn meal, linseed-oil meal, malt sprouts and peanut cake mixed with cocoa molasses. In the sixth period of seven days he gave 1.1 pounds of sesame oil to each cow daily as an emulsion in drinking water. He concludes that "the proportional and absolute fat content of milk is not dependent upon the amount of fat in the food."

We have now reviewed the reports of forty-four separate experiments. They may be classified in the following manner in answer to the question: Was the percentage of fat in the milk increased by the food given the cows?

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* Milch Zeitung 27 (1898) p. 306; p. 323.

† Milch Zeitung 27 (1898) p. 513.

‡ Landwirtschaftliche Jahrbücher 28 (1899) p. 485.

	Yes.	No.	A tendency to increase.
Feeding fat	4	8	1
Feeding protein and mixed foods	3	20	3
Feeding watery foods	—	2	—
Feeding molasses preparations	3	—	—
Total	10	30	4

Of the four experiments where the fat in the food increased the proportion of milk-fat, one reports so great a reduction in the yield as to make such feeding unprofitable. The noted experiment of Soxhlet whereby he increased the per cent of milk-fat by feeding the cows oil emulsified in the drinking water, has been repeated many times by other experimenters, but none of them, so far as we know, have reached a similar result. The protein foods which increased the per cent of fat were palm-nut meal and sugar meal. The molasses preparations may owe their power to increase the fat content of milk to their rather abnormal character.

ORIGINAL EXPERIMENTS.

These experiments were conducted for the purpose of determining the comparative effect of rations having different nutritive ratios upon milk production. This question has been the subject of experimentation at various times and places as has been already noticed, but further investigation along possibly different lines may throw more light upon the problem. Much discussion has occurred over the matter of the length of time during which a particular food should be tested and as to the accuracy of conclusions drawn from feeding trials where two or more foods were given during brief alternating periods. Some contend that four or five weeks is sufficient time in which to secure the true effect of a food, some think that a shorter time, even ten days, is enough, while others hold that the longer the period the more accurate and conclusive the result. It is well known that, when a radical change is made in the food of a cow, the secretion of milk is greatly affected. This is most apparent in the fat content, which may either rise or fall, but is more apt to rise. How long the fluctuation may continue depends upon the ability of the cow to accustom herself to the new feed, which time may be only a few days or it may be weeks. And when the cow has become accustomed to the changed feed, her milk falls back to its normal average composition. However, if the experiment is concluded before this time, or if the feed is again changed, then conclusions drawn therefrom must be more or less warped.

In order that these sources of error might be obviated, we not only continued the experiments for a long period, but also made no changes in the kinds of foods given during the whole time. The feeding trials lasted through two successive winters and for a period of twenty-two weeks during each winter. The effect of the different rations was studied by comparing the influence of each upon the average milk production of the cows used. We think this method to be satisfactory because, in the first place, the cows were so selected as to make the different lots fairly equal as to age, breed and general characteristics; and in the second place, if a given ration will produce any particular effect upon milk production, then this ration will show its influence on the average composition of the milk from the lot of cows to which it is fed when compared with the average composition of milk from other cows on other rations.

Our study is confined to the yield of milk and its quality so far as represented by the percentage of butter-fat. The determinations of fat were made by the Babcock test from samples of milk taken from each cow during the last three days of each week. These daily samples were tested separately and their average taken for the average per cent of fat in the week's milk. Each cow's milk was weighed as soon as drawn and the weekly yield of milk multiplied by the average per cent of fat gives the total fat produced during the week.

The rations fed were of three kinds, one with a narrow, one with a medium, and the third with a wide nutritive ratio. No analyses of foods were made except of the oat chop which was fed during the first year. The amount of dry substance and the nutritive ratio were calculated largely from the average composition of feeding stuffs given in Bulletin No. 11 of the office of Experiment Stations.

With one exception the same cows were used throughout the two years of experiment. Moreover the same cows were fed rations having practically the same nutritive ratio, though made up of different foods during both years, *i. e.* the cows receiving a narrow ration the first year also received a narrow ration the second year and likewise with the cows on other rations. None of the rations are what would be called unusual for similar ones may be found in use on dairy farms in various parts of the country. During the whole length of both experiments it was the aim to give the cows all the food they could readily consume.

The records as published contain only the average data obtained from each lot of cows. In work of this kind, the average record of several cows is of more value than individual records taken singly, and it is from the average record that conclusions must be drawn. For this reason and in order to eliminate many long tables from these pages, the individual records are not published.

THE FIRST EXPERIMENT 1895–6.

This feeding trial began November 6, 1895, and continued for twenty-two weeks until April 7, 1896. It was conducted by James M. Johnson then a graduate student in the college of agriculture. The names of the cows used are given below together with their breed, age, number of days in milk and weight.

Name and breed.	Age.	Number of days in milk.	Weig't, beginning.	Weig't, end.	Gain.
LOT A:					
Garnet Valentine, A. J. C. C., 73873..	4	67	873	992	119
Belva 2d, 15/16 Holstein.............	2	49	891	1088	197
Julia, 7/8 Holstein..................	4	25	1196	1370	174
LOT B:					
Cherry, grade Jersey................	2	49	721	849	128
Dora, 15/16 Holstein.................	4	62	1146	1213	67
Glista 4th, H. F. H. B., 31408.......	3	65	1064	1239	175
LOT C:					
Clara, grade Jersey..................	3	65	922	1063	141
Glista Netherland, H. F. H. B., 32442	3	16	1038	1127	89
May 2d, 7/8 Holstein.................	3	54	1017	1223	206

The daily rations of the cows in each lot were made up as follows :

LOT A :

Grain mixture	8 to 13 pounds.
Gluten feed	3 parts.
Oat chop	2 parts.
Cotton-seed meal	2 parts.
Linseed oil meal	1 part.
Corn silage	40 to 45 pounds.
Clover hay	8 to 10 pounds.
Nutritive ratio	1:4.5

LOT B :

Grain mixture	8 to 10 pounds.
Gluten feed	2 parts.
Oat chop	3 parts.
Corn meal	1 part.
Linseed oil meal	1 part.
Corn silage	35 to 45 pounds.
Clover hay	4 to 10 pounds.
Nutritive ratio	1:6

LOT C :

Grain mixture	8 to 10 pounds.
Oat chop	4 parts.
Corn meal	4 parts.
Linseed oil meal	1 part.
Corn silage	35 to 40 pounds.
Timothy hay	4 to 8 pounds.
Nutritive ratio	1:9

Calculating each of these rations on the basis of 8 pounds of grain, 8 pounds of hay and 40 pounds of silage, each cow would receive the following number of pounds of digestible nutrients per day :

	Protein.	Carbohydrates.	Fat.	Nutritive ratio.
Lot A. narrow ration	2.90	10.78	1.09	1:4.5
Lot B. medium ration	2.25	11.61	.91	1:6.0
Lot C. wide ration	1.60	12.68	.75	1:9.0

Beginning with December 14, each cow received 5 pounds of mangel-wurtzels per day in addition to the above rations.

Table I contains the average record of consumption of food and production of milk and fat for each of the three lots of cows named above. The data given includes the weekly average consumption of dry matter per head, the average daily consumption per 1000 pounds live weight, the nutritive ratio, the average weekly yield of milk and fat and the average per cent of fat.

TABLE I—1895-6.

AVERAGE RECORD OF LOT A. (NARROW RATION).

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs daily.	Nutritive Ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	159.46	23.34	1:4.53	219.50	3.64	7.98
2	164.01	23.59	1:4.50	221.33	3.20	7.08
3	164.71	23.66	1:4.50	220.92	3.35	7.41
4	166.27	23.24	1:4.51	208.67	3.55	7.41
5	170.55	23.46	1:4.43	202.42	3.52	7.13
6	171.19	23.26	1:4.38	200.33	3.42	6.85
7	175.05	23.65	1:4.35	196.33	3.22	6.36
8	177.32	23.72	1:4.32	199.00	3.39	6.75
9	170.55	22.61	1:4.28	191.00	3.31	6.32
10	171.11	22.64	1:4.29	195.67	3.23	6.32
11	171.96	22.74	1:4.29	197.08	3.39	6.68
12	174.19	22.92	1:4.24	191.25	3.26	6.24
13	173.20	22.74	1:4.20	191.08	3.47	6.63
14	178.43	23.48	1:4.26	183.75	3.60	6.62
15	180.12	23.58	1:4.27	184.42	3.61	6.67
16	180.97	23.55	1:4.28	191.33	3.50	6.74
17	180.69	23.37	1:4.28	186.42	3.53	6.59
18	176.73	22.68	1:4.25	169.50	3.53	5.98
19	177.44	22.57	1:4.26	176.83	3.86	6.83
20	178.71	22.56	1:4.23	177.17	3.63	6.44
21	179.13	22.45	1:4.27	166.83	3.60	6.01
22	179.16	22.26	1:4.27	166.67	3.62	6.04

TABLE I—(*Continued*).

AVERAGE RECORD OF LOT B. (MEDIUM RATION.)

Week.	Dry matter consumed.			Weekly product of milk and fat Average per head.		
	Per head weekly.	Per 1000 lbs. daily.	Nutritive ratio.	Pounds of milk.	Per cent fat.	Pounds of fat
1	162.25	24.03	1:6.12	187.50	3.35	6.27
2	161.42	23.70	1:6.11	191.42	3.33	6.37
3	161.55	23.56	1:6.11	182.50	3.38	6.17
4	162.26	23.57	1:6.12	180.75	3.58	6.47
5	165.52	23.77	1:6.05	175.75	3.19	5.61
6	167.28	23.81	1:6.03	166.50	3.44	5.73
7	171.70	24.25	1:5.97	177.75	3.28	5.82
8	173.29	24.16	1:5.94	167.58	3.16	5.30
9	167.81	23.53	1:5.89	164.75	3.05	5.02
10	163.72	22.66	1:5.89	167.33	3.07	5.14
11	171.23	23.51	1:5.96	169.25	3.45	5.84
12	168.72	23.14	1:5.96	164.92	3.32	5.48
13	170.11	23.29	1:5.95	165.67	3.32	5.49
14	168.18	23.05	1:5.88	152.83	3.40	5.20
15	169.63	23.47	1:5.93	154.08	3.60	5.55
16	173.43	23.44	1:5.95	162.83	3.50	5.70
17	174.34	23.49	1:5.96	159.17	3.52	5.60
18	173.46	23.21	1:5.96	156.50	3.59	5.61
19	173.21	23.00	1:5.96	152.67	3.73	5.69
20	173.77	22.91	1:5.96	154.67	3.53	5.46
21	174.48	22.86	1:5.96	146.42	3.51	5.14
22	173.35	22.50	1:5.96	125.33	3.84	4.81

TABLE I—(*Continued*).

AVERAGE RECORD OF LOT C. (WIDE RATION).

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs. daily.	Nutritive ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	150.20	21.56	1:8.79	180.83	3.31	5.99
2	149.62	21.28	1:8.78	177.92	3.20	5.69
3	145.43	20.52	1:8.73	173.83	3.54	6.16
4	146.73	20.49	1:8.73	166.75	3.55	5.92
5	151.28	20.95	1:8.65	162.00	3.37	5.46
6	147.63	20.35	1.8.43	152.67	3.43	5.24
7	150.14	20.50	1:8.30	164.25	3.08	5.06
8	147.16	19.93	1:8.19	164.92	3.22	5.31
9	148.75	20.07	1:8.22	145.25	3.74	5.43
10	146.44	19.62	1:8.18	154.92	3.25	5.03
11	151.65	20.17	1:8.27	154.25	3.30	5.08
12	146.15	19.33	1:8.16	153.42	3.31	5.08
13	147.62	19.45	1:8.21	153.67	3.37	5.18
14	146.49	19.21	1:8.19	147.75	3.21	4.75
15	147.31	19.27	1:8.19	143.17	3.60	5.15
16	154.39	20.16	1.8.33	146.83	3.45	5.07
17	156.13	20.33	1:8.36	146.33	3.29	4.82
18	156.13	20.29	1:8.36	142.75	3.52	5.02
19	157.72	20.33	1:8.39	139.92	3.87	5.42
20	158.73	20.26	1:8.41	141.67	3.58	5.07
21	160.76	20.32	1:8.45	136.50	3.65	4.98
22	161.01	20.56	1:8.46	135.33	3.63	4.91

THE SECOND EXPERIMENT, 1896-7.

This feeding trial continued for twenty-two weeks from November 11, 1896 to April 13, 1897 and was conducted by the writer. The names of the cows used are given below together with their breed, age, number of days in milk and weight. It will be noticed that these cows are the same that were in the first experiment with the exception of Jennie 2d, in lot C who took the place of Glista Netherland.

Name and breed.	Age.	Number of days in milk.	Weig't, beginning.	Weig't, end.	Gain.
LOT A:					
Garnet Valentine, A. J. C. C. 73873	5	74	920	1020	100
Belva 2d, 15/16 Holstein	3	50	1012	1200	188
Julia, 7/8 Holstein	5	62	1247	1333	106
LOT B:					
Cherry, grade Jersey	3	54	809	928	119
Dora, 15/16 Holstein	5	Calved Nov. 20.	1181	1213	32
Glista 4th, H. F. H. B. 31408	4	60	1137	1289	152
LOT C:					
Clara, grade Jersey	4	68	1030	1062	32
Jennie 2d, Jersey-Holstein	3	Calved Nov. 8.	857	952	95
May 2d, 7/8 Holstein	4	44	1124	1191	67

The daily rations of the cows in each lot were made up as follows:

LOT A:	
Grain mixture	8 to 12 pounds.
Gluten feed	3 parts.
Cotton seed meal	2 parts.
Wheat bran	1 part.
Corn silage	35 to 45 pounds.
Clover hay	6 to 12 pounds.
Nutritive ratio	1:4.3
LOT B:	
Grain mixture	8 to 12 pounds.
Gluten feed	2 parts.
Corn meal	2 parts.
Wheat bran	2 parts.
Linseed oil meal	1 part.
Corn silage	35 to 45 pounds.
Clover hay	6 to 12 pounds.
Nutritive ratio	1:5.7
LOT C:	
Grain mixture	8 to 11 pounds.
Corn meal	2 parts.
Wheat bran	1 part.
Corn silage	35 to 40 pounds.
Timothy hay	4 to 8 pounds.
Nutritive ratio	1:9.3

Calculating each of these rations on the basis of eight pounds of grain, eight pounds of hay, and 40 pounds of silage, each cow would receive the following number of pounds of digestible nutrients per day.

	Protein.	Carbo-hydrates.	Fat.	Nutritive Ratio.
Lot A, narrow ration........	3.08	10.63	1.13	1:4.3
Lot B, medium ration.......	2.37	11.67	.87	1:5.7
Lot C, wide ration..........	1.56	12.96	.67	1:9.3

Beginning with January 6, each cow was fed five pounds of mangel-wurtzels per day, which amount was increased to 10 pounds in a few days and so continued until the close of the experiment. Table II contains the average record of consumption of food and production of milk and fat for each of the three lots of cows named above. The data given includes the weekly average consumption of dry matter per head, the average daily consumption per 1000 pounds live weight, the nutritive ratio, the average weekly yield of milk and fat and average per cent of fat.

TABLE II.

AVERAGE RECORD OF LOT A. (NARROW RATION.)

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs. daily.	Nutritive ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	167.19	22.63	1:4.15	184.42	3.37	6.21
2	169.34	22.53	1:4.11	188.33	3.31	6.24
3	172.81	22.67	1:4.11	187.75	3.27	6.14
4	172.98	22.32	1:4.00	178.25	3.44	6.13
5	169.36	21.82	1:3.94	177.08	3.21	5.64
6	175.30	22.48	1:4.01	176.17	3.20	5.64
7	176.12	22.47	1:4.03	166.50	3.25	5.41
8	178.18	22.61	1:4.04	169.92	3.08	5.24
9	163.61	20.50	1:3.98	153.33	3.26	5.00
10	142.36	18.59	1:4.12	150.58	3.37	5.08
11	169.11	21.52	1:4.03	161.75	3.27	5.28
12	163.36	20.74	1:3.96	152.08	3.17	4.82
13	169.52	21.56	1:3.95	147.92	3.15	4.66
14	171.13	21.55	1:3.90	156.83	3.34	5.23
15	173.60	21.76	1:3.93	155.67	3.26	5.08
16	178.23	22.07	1:3.92	150.58	3.22	4.85
17	182.63	22.51	1:3.94	152.25	3.21	4.88
18	179.27	21.93	1:3.93	151.17	3.41	5.15
19	176.46	21.52	1:3.92	148.83	3.32	4.94
20	174.74	21.16	1:3.91	148.58	3.31	4.92
21	175.69	21.20	1:3.91	150.75	3.37	5.09
22	174.61	20.87	1:3.90	143.50	3.36	4.83

TABLE II—(*Continued*).

AVERAGE RECORD OF LOT B. (MEDIUM RATION.)

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs. daily.	Nutritive ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	*162.22	23.96	1:5.58	*182.75	3.67	6.72
2	*164.89	23.76	1:5.54	*189.25	4.04	7.64
3	*166.15	23.44	1:5.54	*181.75	3.83	6.97
4	164.90	21.87	1:5.59	221.08	3.84	8.50
5	169.20	22.42	1:5.53	227.33	3.43	7.79
6	164.48	21.80	1:5.54	195.17	3.98	7.77
7	170.53	22.53	1:5.56	204.25	3.63	7.42
8	175.99	23.20	1:5.59	214.92	3.34	7.19
9	177.14	23.37	1:5.94	217.42	3.42	7.42
10	180.81	23.87	1:5.93	216.16	3.36	7.26
11	176.58	23.32	1:5.46	210.33	3.51	7.38
12	166.01	21.85	1:5.42	201.50	3.40	6.89
13	175.91	23.27	1:5.47	204.58	3.47	7.09
14	178.59	23.14	1:5.46	207.08	3.51	7.27
15	184.10	23.92	1:5.47	215.92	3.50	7.55
16	186.78	24.03	1:5.47	205.17	3.57	7.33
17	186.35	23.75	1:5.47	208.42	3.43	7.16
18	186.92	23.73	1:5.47	214.42	3.45	7.39
19	182.40	23.09	1:5.46	209.00	3.65	7.63
20	181.98	22.94	1:5.46	208.33	3.41	7.11
21	181.27	22.76	1:5.46	202.25	3.62	7.33
22	181.55	22.65	1:5.46	199.83	3.55	7.09

* Average for two cows.

TABLE II—(*Continued*).

AVERAGE RECORD OF LOT C. (WIDE RATION).

Week.	Dry matter consumed.			Weekly product of milk and fat. Average per head.		
	Per head weekly.	Per 1000 lbs. daily.	Nutritive ratio.	Pounds of milk.	Per cent fat.	Pounds of fat.
1	*129.38	17.37	1:8.87	* 179.75	3.63	6.53
2	141.92	20.56	1:9.02	189.08	3.96	7.49
3	147.75	21.21	1:8.99	186.25	3.95	7.36
4	144.32	20.71	1:8.95	174.17	4.09	7.12
5	135.80	19.52	1:8.79	169.92	3.89	6.61
6	149.93	21.48	1:9.08	169.33	3.78	6.39
7	153.89	21.97	1:9.12	156.75	3.63	6.18
8	156.10	22.23	1:9.15	169.42	3.73	6.32
9	155.15	22.12	1:8.90	167.50	3.99	6.68
10	158.99	22.56	1:8.76	161.42	4.05	6.54
11	158.09	22.37	1:8.75	160.92	4.06	6.53
12	152.95	21.53	1:8.75	157.08	4.10	6.44
13	159.51	22.42	1:8.80	155.83	4.06	6.32
14	158.27	22.04	1:8.69	157.42	4.06	6.39
15	159.68	22.44	1:8.69	158.33	3.99	6.32
16	152.38	20.90	1:8.55	147.92	4.18	6.18
17	154.93	21.04	1:8.56	153.42	4.06	6.23
18	157.59	21.37	1:8.61	151.67	4.06	6.16
19	151.51	20.40	1:8.51	146.25	4.16	6.08
20	* 160.50	21.62	1:8.53	* 161.38	3.64	5.88

*Average for two cows.

Before entering upon any discussion of these records it is necessary to make a few explanations in order that a clear understanding of them may be obtained. The first experiment went through without any irregularities, or illness of the cows, sufficient to cause variations that should be noticed when drawing conclusions. But during the second experiment there were some irregularities that need to be noticed.

In lot A, Table II, Julia was taken sick during the ninth week of the test and for a few days her milk yield fell off nearly one-half. Her illness and slow recovery considerably reduced the average milk and fat yield as may be seen by a glance at the table.

In lot B, Dora did not enter the experiment until the fourth week and was then fresh in milk. She was giving from 40 to 50 pounds of milk daily, which amount increased the average yield, as is seen in table II. During the sixth week she was "off feed" and her milk fell from 325 pounds, during the fifth week to 232 pounds. At the same time her average per cent of fat was over one per cent higher than during the week previous, as well as during the following week. This explains the high average of 3.98 per cent during the sixth week. She quickly regained nearly her former flow and at the close of the experiment was averaging 42 pounds per day.

In lot C, Jennie calved November 8 and entered the experiment the second week, fresh in milk. Her coming into this lot increased both the average yield of milk and the per cent of fat for the second and succeeding weeks. During the twentieth week, Clara, of lot C, was taken suddenly ill with a high fever and died. Upon examination, she was found to have accumulations of fatty tissue in close proximity to the vital organs. During the twenty-first week, May, of lot C, was taken ill in a similar manner to Clara, but her life was saved. It will be remembered that the cows in this lot received a highly carbonaceous ration. The grain consisted of two parts, by weight, of corn meal and one part of wheat bran, while the silage was rich in corn and had been increased five pounds each about a month before the cows became sick. It may be that so highly carbonaceous a ration has a heating tendency upon the animal body. If this be the case, feeding the ration for so long a period, might, in its cumulative effects, result as disastrously as mentioned above. Although Jennie 2d came through the experiment safely on the same ration, still, when the effect upon Clara and May is considered, we cannot help concluding that the ration is not a good one for long, continuous feeding.

To return to the study of the comparative effect of the three rations upon the yield and quality of milk, the results show that there is practically no difference between them so far as their effect on the percentage of fat is concerned. In general there is a gradual increase in the richness of the milk from the beginning of each experiment until the end, regardless of the kind of food. An average of the per cents of fat for periods of four weeks each will present the fact more clearly, and such an average is given in tabular form below. The first two weeks are omitted in striking the average in all cases.

	1895-6. Lot and kind of ration.			1896-7. Lot and kind of ration.		
	A Narrow. per cent fat.	B Medium. per cent fat.	C Wide per cent fat.	A Narrow per cent fat,	B Medium per cent fat.	C Wide. per cent fat.
1st four weeks........	3.46	3.40	3.47	3.29	3.77	3.93
2nd four weeks........	3.29	3.14	3.32	3.24	3.44	3.85
3d four weeks.........	3.44	3.37	3.27	3.23	3.47	4.07
4th four weeks........	3.54	3.55	3.47	3.28	3.49	4.07
5th four weeks........	3.68	3.65	3.68	3.34	3.56	——

An average of this kind balances the variations from week to week, and places the per cents of fat in a light where conclusions can be more readily drawn therefrom. The reason for the high average during the first four weeks in lot B, year 1896–7, has already been indicated in the discussion concerning Dora's entering the experiment when fresh in milk, and later becoming reduced in flow and increased in fat by forced feeding. Omitting this period, it will be noticed that the average for the remaining periods bear the same relation to each other as those for lot A. In the first experiment there was an increase from the beginning to the end with each lot of about two-tenths of one per cent of fat. In the second experiment this increase was about one-tenth of one per cent.

When we examine the yield of milk and of fat we do not find the same uniformity as is observed in the per cent of fat. If an average be taken of the yield of milk and fat for the first four weeks after the first two, and for the last four weeks of the experiments we find the following per cent of decrease from beginning to end:

	1895-6. Lot and kind of ration.			1896-7. Lot and kind of ration.		
	A Narrow.	B Medium.	C Wide.	A Narrow.	B Medium.	C Wide.
Per cent decrease in milk	17.5	18.0	15.5	17.8	3.0	14.4
Per cent decrease in fat	12.0	12.0	12.0	15.6	6.0	10.3

The decrease for 1895–6 was the same with all rations except for a slight difference in favor of the cows receiving the wide ration. During the year 1896–7 the yields are not so uniform, but lot B shows a much smaller decrease than either of the other lots. Taking both experiments into account it would seem that the medium ration had a more favorable influence upon the continued production of milk and total butter-fat than either the wide or narrow rations. Yet, if individual cases are considered, we find Belva 2d, on the narrow ration, holding out in her milk flow during both years as well as, or better than, any of the cows on the medium ration.

NUMBER OF POUNDS OF DRY MATTER REQUIRED IN EACH RATION TO PRODUCE 100 POUNDS OF MILK AND ONE POUND OF FAT.

	LOT A. Narrow ration.		LOT B. Medium ration.		LOT C. Wide ration.	
	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.
1895–6......	90.2	26.0	102.8	30.1	98.3	28.7
1896–7......	106.6	32.3	85.2	23.9	92.8	23.4
Average...	97.5	28.8	93.0	26.6	95.7	25.9

WEIGHT OF COWS.

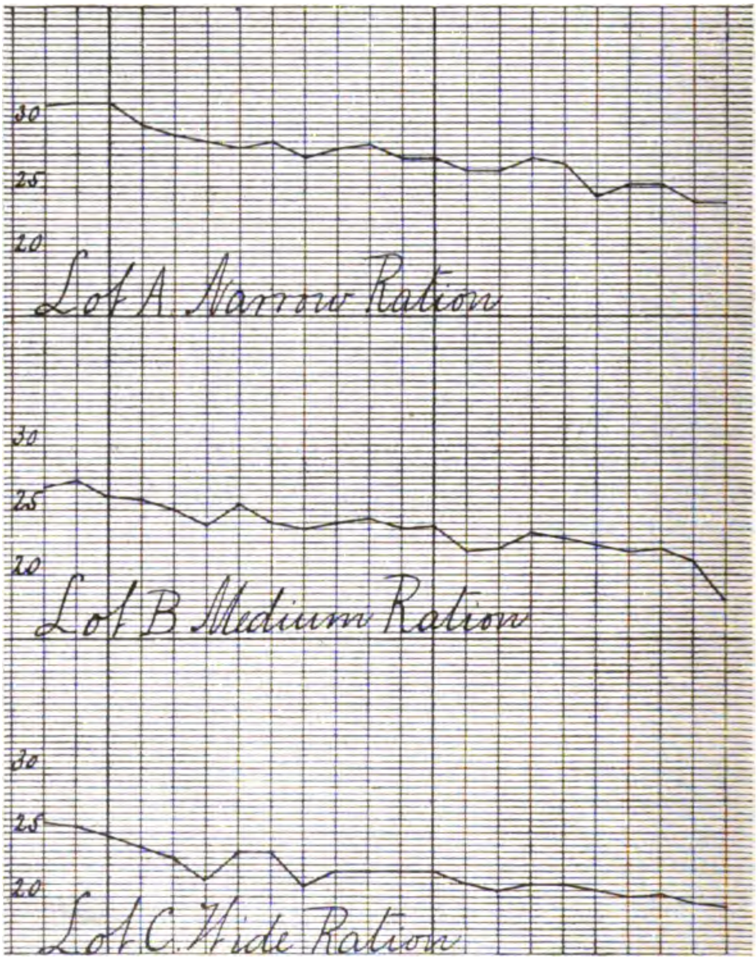
Whether or not the different rations had any particular effect upon the live weight of the cows may be studied by recourse to data already given, but an average of the gain of each lot during the twenty-two weeks together with their average age is tabulated here, for more ready reference. During the first year none

	LOT A. Narrow ration.		LOT B. Medium ration.		LOT C Wide ration.	
	Age.	Gain per head.	Age.	Gain per head.	Age.	Gain per head.
1895-6......	3⅓	163	3	123	3	145
1896–7......	4⅓	131	4	101	3⅔	65

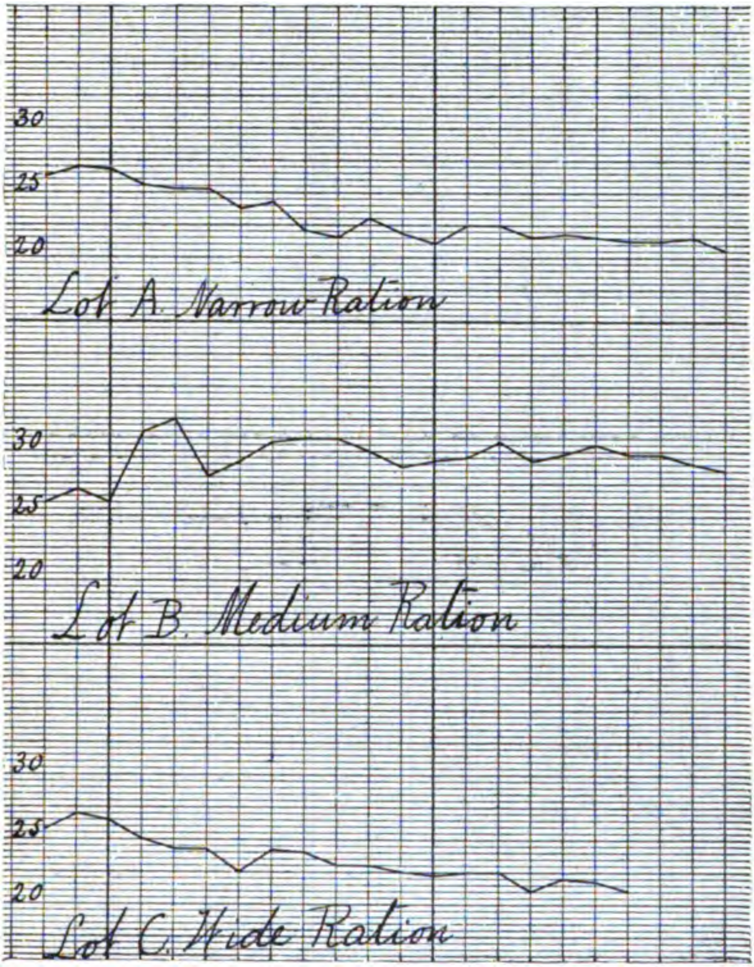
of the cows had reached full age and during the second year two of lot A and one of lot B were five years old. Since the cows in lot A were older than the others, it might seem that the narrow ration had a tendency to fatten the animals more than the other rations. However, the differences are so slight that it is safe to say that the gains in weight are due more to growth than to any particular effect of the food.

CHARTS.

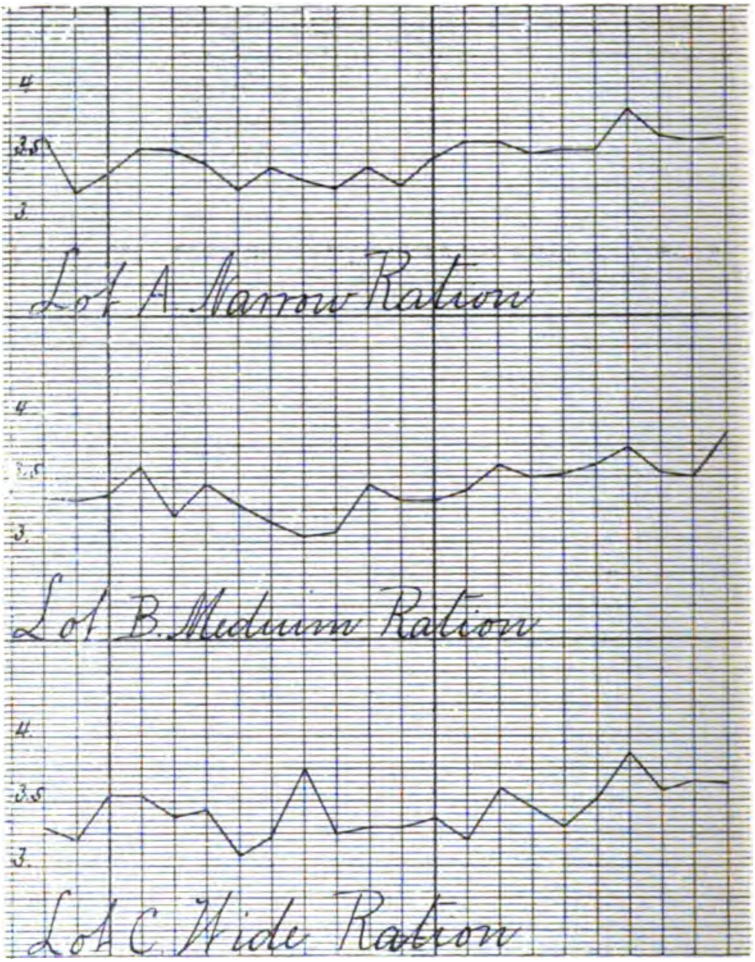
In order to place the records for milk and fat presented in tables I and II more vividly before the reader's eye the following six charts have been prepared. They show the average daily yield of milk, average per cent of fat and average weekly yield of fat for both experiments. Passing from left to right in the charts each division represents one week. Counting upward, each of the small spaces represents one-half pound of milk, five-one hundredths of one per cent fat, or one-tenth of a pound of fat as the case may be.



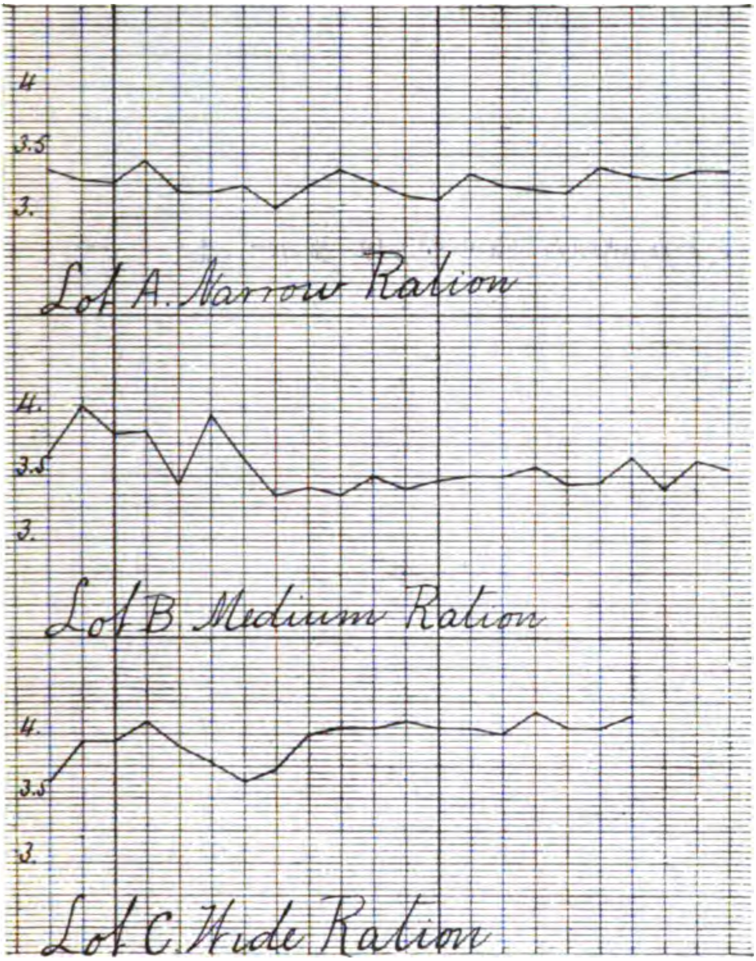
16.—*Diagram showing the average daily yield of milk for each week during the experiment of 1895–6. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents one-half pound of milk.*



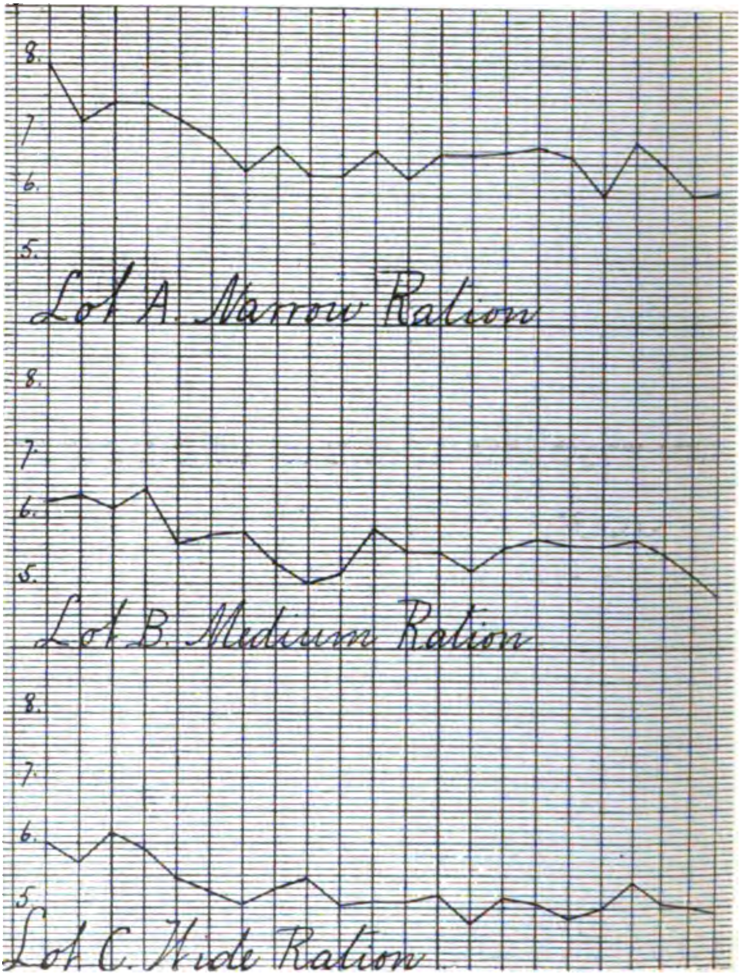
17.—*Diagram showing the average daily yield of milk for each week during the experiment of 1896–7. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents one-half pound of milk.*



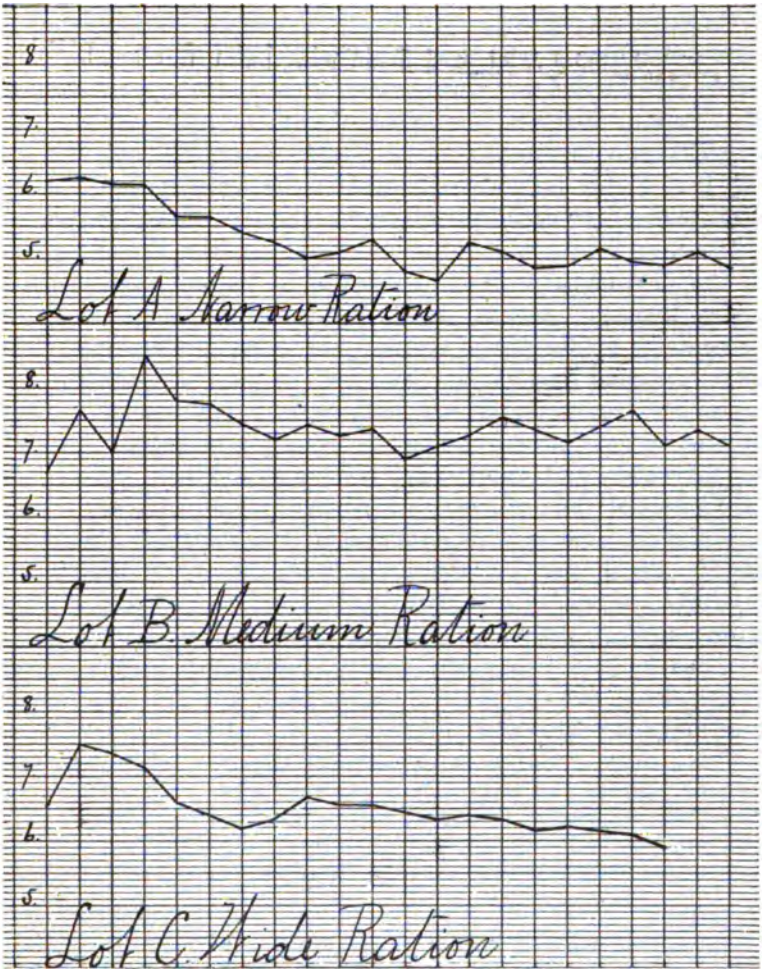
18.—*Diagram showing the average per cent of fat for each week during the experiment of 1895-6. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents five one-hundredths of one per cent of fat.*



19.—*Diagram showing the average per cent of fat for each week during the experiment of 1896-7. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents five one-hundredths of one per cent of fat.*



20.—*Diagram showing the average weekly yield of butter fat during the experiment of 1895–6. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents one-tenth of one pound of fat.*



21.—*Diagram showing the average weekly yield of butter fat during the experiment of 1896-7. Each space between the perpendicular lines represents one week. Each space between the horizontal lines represents one-tenth of one pound of fat.*

FEEDING PALM NUT MEAL.

To carry still further the study of the effect of food upon milk production a trial was made with palm nut meal. This work was carried on during the winter of 1897 by George N. Lauman, then a Senior in the College of Agriculture. An experiment with this food has a double interest because it is the one that Kühn found would increase the per cent of fat in the milk as has been seen in the summary of his work on page 52.

Palm nut meal is the by-product resulting from the extraction of the oil from the fruit of a species of palms which are native to the west coast of Africa. It is a highly nitrogenous product, its percentage of digestible composition being protein 16.6, fiber 16.6, nitrogen free extract 41.4 and fat 3.6. In Europe, and especially Germany, it has long been a popular dairy food because of its stimulative effect upon milk production, although not all feeders and experimenters have found it to increase the fat content of the milk as was reported by Kühn.

The meal used in this experiment was imported from Germany. Six of the University cows were chosen for the test and divided into two lots of three each. Before giving them the palm nut meal, their regular daily ration had consisted of from 8 to 10 pounds of a grain mixture composed of three parts gluten feed, two parts cotton-seed meal, and one part wheat bran, together with what silage and mixed hay they would eat.

The names of the cows in each lot, together with their age, date of calving and weights are given below:

Name of breed.	Age.	Date of calving.	Weight beginning.	Weight end.	Loss.
LOT NO. 1.					
Glista Netherland, H. F. H. B. 32442	5	Oct. 21, 1895.	1339	1289	50
Gem Valentine, A. J. C. C. 57881 ...	8	Sept. 6, 1896,	1071	973	98
Mollie, $\frac{15}{16}$ Holstein	7	Oct. 24, 1896.	1348	1267	81
LOT NO. 2.					
Mabel 2d, Jersey-Holstein	2	Oct. 15, 1896.	902	832	70
Ruby, $\frac{3}{4}$ Holstein	8	Dec. 26, 1896.	1369	1191	178
Sadie, $\frac{15}{16}$ Holstein	5	May 1, 1896.	1407	1386	21

The feeding of the palm nut meal began January 20, 1897, and continued for six weeks. During this time the ration of lot No. 1 remained constant, while that of lot No. 2 was increased as indicated below. The daily rations were made up as follows:

LOT No. 1:

Grain mixture	10 to 13 pounds.
Palm nut meal	2 parts.
Gluten feed	2 parts.
Wheat bran	1 part.
Corn silage	35 to 45 pounds.
Mixed hay	10 to 13 pounds.
Nutritive ratio	1:6.

Calculating this ration on the basis of 10 pounds of grain, 10 pounds of hay and 40 pounds of silage it would contain the following number of pounds of digestible nutrients: protein 2.7, carbohydrates 14.1, fat .96 and 26 pounds of dry substance.

LOT No. 2:

Grain mixture.	
Palm nut meal	4 parts.
Gluten feed	3 parts.
Cotton-seed meal	2 parts.
Wheat bran	1 part.
Corn silage	35 to 45 pounds.
Mixed hay	7 to 10 pounds.

The amount of coarse fodder given this lot did not vary materially during the whole experiment. The quantity of the grain mixture fed was increased as follows:

	January 20–31.	February. 1–6.	February. 7–28.
Mabel	7	8.5	10
Ruby	10	12	14
Sadie	10	12	14

Calculating this ration according to the quantities eaten by Ruby and Sadie and considering the amount of silage and hay consumed as 40 and 10 pounds respectively, we have the following amounts of dry matter and the number of pounds of digestible nutrients consumed daily during the different periods:

	Dry matter.		Protein.	Carbohydrates.	Fat.	Nutritive ratio
	Per head.	Per 1000 lbs.				
January 20–31	26.06	20.00	3.09	13.52	1.08	1:5.16
February 1–6	27.87	21.51	3.52	14.42	1.22	1:4.84
February 7–28	29.68	22.83	3.96	15.32	1.35	1:4.64

On February 24 the proportion of palm nut meal was increased from four to six parts in the grain mixture so that it made up one-half of the grain ration. On the first of March the meal was discontinued and all the cows returned to the same ration which they received before the trial.

Table III contains the yield of milk and butter-fat of each cow under experiment for six weeks before and six weeks after the palm nut meal was fed as well during the period of feeding the meal.

TABLE III.

WEEKLY PRODUCT OF MILK AND FAT OF LOT NO. 1.

Ration for each period of six weeks.	Glista Netherland.			Gem Valentine.			Mollie.		
	Pounds of milk.	Per cent fat.	Pounds of fat.	Pounds of milk.	Per cent fat.	Pounds of fat.	Pounds of milk.	Per cent fat.	Pounds of fat.
Usual ration of silage, hay and grain.	204.25	3.00	6.13	157.00	5.20	8.16	334.25	2.60	8.69
	217.50	3.15	6.85	176.50	5.30	9.35	347.50	2.95	10.25
	207.50	3.00	6.23	145.50	5.35	7.78	321.50	3.40	10.93
	211.00	3.25	6.86	116.00	4.85	5.63	313.50	3.00	9.41
	202.75	3.25	6.59	118.50	4.85	5.75	305.50	2.65	8.10
	201.50	3.50	7.05	131.25	5.50	7.22	299.50	3.10	9.28
Total.	1244.50	3.19	39.71	844.75	5.20	43.89	1921.75	2.95	56.66
Palm nut meal ration.	206.50	3.20	6.61	127.75	5.52	7.05	311.00	3.17	9.86
	196.50	3.38	6,64	123.25	5.88	7.25	293.50	3.26	9.57
	182.25	3.41	6.21	122.75	6.00	7.37	295.25	3.38	9.98
	187.00	3.75	7.01	117.75	5.98	7.04	296.75	3.48	10.33
	184.00	3.48	6.40	117.50	5.57	6.54	298.75	3.35	10.01
	164.75	3.75	6.18	105.50	5.85	6.17	295.00	3.53	10.41
Total.	1121.00	3.48	39.05	714.50	5.80	41.42	1790.25	3.36	60.16
Usual ration.	139.50	3.42	4.77	111.50	5.73	6.39	285.50	3.07	8.76
	* 62.00	3.60	2.23	114.75	6.00	6.89	315.50	3.30	10.41
				108.00	5.65	6.10	304.00	3.55	10.79
				83.75	5.95	4.98	307.75	3.25	10.00
				93.25	5.75	5.36	294.00	3.40	10.00
				93.75	5.85	5.48	290.75	3.25	9.45
Total.	201.50	3.47	7.00	605.00	5.82	35.20	1797.50	3.31	59.41

* Went dry.

TABLE III—(*Continued*).

WEEKLY PRODUCT OF MILK AND FAT OF LOT NO. 2.

Ration for each period of six weeks.	Mabel 2d.			Ruby.			Sadie.		
	Pounds of milk.	Per cent fat.	Pounds of fat.	Pounds of milk.	Per cent fat.	Pounds of fat.	Pounds of milk.	Per cent fat.	Pounds of fat.
Usual ration of silage, hay and grain.	183.75	3.90	7.17				169.75	3.20	5.43
	186.25	4.10	7.64				163.50	3.05	4.99
	163.25	3.80	6.20				147.00	3.40	5.00
	167.50	3.95	6.62	336.25	3.75	12.61	141.25	3.60	5.09
	176.00	3.90	6.86	385.25	3.80	14.64	148.00	3.45	5.11
	171.00	3.45	5.90	408.00	3.50	14.28	144.50	3.90	5.64
Total	1047.75	3.85	40.39	1129.50	3.67	41.53	914.00	3.42	31.26
Palm nut meal ration.	160.25	4.07	6.52	434.25	3.26	14.16	132.25	3.22	4.26
	148.75	4.58	6.81	439.00	3.28	14.40	119.75	3.28	3.93
	150.75	4.33	6.53	418.75	3.25	13.61	119.50	3.33	3.98
	152.00	4.53	6.89	423.25	3.26	13.80	122.50	4.06	4.97
	148.75	4.35	6.47	422.25	3.21	13.55	122.75	3.23	3.96
	149.50	4.18	6.25	415.75	3.35	13.93	113.75	3.46	3.94
Total	910.00	4.34	39.47	2553.25	3.27	83.45	730.50	3.43	25.04
Usual ration.	162.25	3.69	5.99	409.50	3.00	12.29	104.25	3.12	3.25
	169.75	3.80	6.45	389.50	3.20	12.75	104.75	2.30	2.41
	170.50	3.85	6.56	422.75	2.80	11.84	97.75	3.40	3.32
	171.00	4.00	6.84	397.50	3.25	12.92	86.75	3.30	2.86
	173.25	4.35	7.54	374.25	3.25	12.16	77.50	3.70	2.87
	174.00	3.75	6.53	345.50	2.90	10.02	67.25	3.45	2.32
Total	1020.75	3.91	39.91	2348.00	3.07	71.98	538.25	3.16	17.03

A clearer understanding of the variations in the per cent of fat during the eighteen weeks may be obtained by finding the average per cent in periods of three weeks each. A table of such averages is given below. In order to make the study more complete, there is placed in the same table the average per cents of fat found in the records of three cows which were in the second experiment described on page 65. The per cents are the averages for the periods of three weeks each which are coincident with those in which palm nut meal was fed. It will be remembered that the rations of the three cows were unaltered during a term of twenty-two weeks.

TABLE IV.

AVERAGE PER CENT OF FAT IN PERIODS OF THREE WEEKS EACH.

		Lot No. 1.			Lot No. 2.		
		Glista Netherland.	Gem Valentine.	Mollie.	Mabel 2d.	Ruby.	Sadie.
Usual ration (Dec. 9-Jan. 19)..	1st three weeks.	3.06	5:28	2.98	3.94	——	3.21
	2d three weeks.	3.39	5:09	2.92	3.77	3.67	3.63
Palm nut meal ration.......... (Jan. 20-Mch. 2).	1st three weeks.	3.32	5:80	3.27	4.32	3.26	3.28
	2d three weeks.	3.64	5:80	3.45	4.35	3.27	3.58
Usual ration.... (Mch. 3-April 13).	1st three weeks.	3.47	5:80	3.31	3.78	3.00	2.92
	2d three weeks.	——	5:84	3.30	4.03	3.14	3.48

Ration unchanged.	Belva 2d. Narrow ration.	Cherry. Medium ration.	Clara. Wide ration.
December 9-29................	3.02	5.37	5.11
December 30-Jan. 19...........	2.92	5.58	5.30
January 20-Feb. 9.............	2.94	5.75	5.68
February 10-Mar. 2............	3.14	5.52	5.44
March 3-23....................	3.23	5.55	5.45
March 24-April 13.............	3.23	5.47	——

Among the cows that were fed palm nut meal it is seen that all in lot No. 1 show in general a higher per cent of fat while the meal was fed than before, but this higher average is kept up for six weeks after the meal was discontinued. Mabel 2d of lot No. 2, is the only cow that shows a lower average both before and after feeding the palm nut meal than during that period, but her total yield of fat was less on the palm nut ration than on the usual ration. Ruby and Sadie each had a higher average before the meal was fed and nearly as high after as during the period of feeding the meal. Ruby's high average at the beginning is probably due to her being fresh in milk. A comparison of the records of all the cows in table IV shows that with one exception (Gem Valentine) there are no greater variations among the cows which alternated from the usual ration to palm nut meal than among those which were fed an unchanging ration. Thus, taking everything into consideration we do not feel warranted in saying that the feeding of palm nut meal increased the per cent of fat in the milk.

CONCLUSIONS.

For two terms of twenty-two weeks, nine cows were fed in lots of three each on different rations, the nutritive ratios of which were about 1:4, 1:6 and 1:9 respectively. During this time the percentage of fat in the milk of each lot increased slightly and gradually without regard to the kind of ration.

For continuous feeding, the medium ration appeared to give better results as to yield of milk than either the narrow or wide rations.

When the food of the cows was changed from the usual ration to one containing from four to seven pounds of palm nut meal and then to the usual ration again, there were variations in the fat content of the milk, but no more nor greater than when the food of the cows was unchanged.

The Following Bulletins are Available for Distribution to Those Who may Desire Them.

40 Removing Tassels from Corn, 9 pp.
55 Greenhouse Notes, 31 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
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168 Studies and Illustrations of Mushrooms: II.
169 Studies in Milk Secretion.
170 Tent Caterpillars.
171 Concerning Patents on Gravity or Dilution Separators.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1899.

171. Gravity or Dilution Separators.
172. The Cherry Fruit-Fly: A New Cherry Pest.
173. The Relation of Food to Milk-Fat.

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Bulletin 174. **November, 1899.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y. [redacted]

THE PROBLEM OF
Impoverished Lands.

Being Suggestions for Investigation and Experiment.

COMPILED BY

L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1899.

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CORNELL UNIVERSITY, ITHACA, N. Y., Nov. 1, 1899.
HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The one perennial inquiry at an Experiment Station is how to restore land to its original producing power. We have made many experiments and investigations to determine the problems at issue. A popular summary of these studies is given herewith. The chemical part of the subject has been prepared by G. W. Cavanaugh, under the supervision of Professor Caldwell. Full reports of three years' experimenting with fertilizers are now being compiled for publication in bulletin form.

This bulletin comprises the following subjects:

Part I. *How to Understand the Problem.*
  A. Some reasons why lands become impoverished.
  B. How to reclaim depleted lands.
Part II. *A Crusade with the Farmers.*
  A. Reading-Lessons Nos. 1 and 2.
    No. 1. The Soil: What it is.
    No. 2. Tillage and under-drainage: Reasons why.
  B. Answers to the Questions on Five Reading-Lessons.
    No. 1. The Soil: What it is.
    No. 2. Tillage and under-drainage: Reasons why.
    No. 3. Fertility of the land: What it is.
    No. 4. How the plant gets its food from the Soil.
    No. 5. How the plant gets its food from the Air.

I. P. ROBERTS, Director.

Plan of a set of plats upon which the farmer may ask the soil and the plant what fertilizers are needed (See p. 95):

1	S plat.			
2	K plat.	20 lbs. muriate of potash.		
3	N plat.	20 lbs. nitrate of soda, or 40 lbs. tankage or dried blood.		
4	K N plat.	20 lbs muriate of potash. 20 lbs. nitrate of soda.	or	20 lbs. muriate of potash. 40 lbs. tankage, etc.
5	O plat.	No fertilizer.		
6	P plat.	40 lbs. plain superphosphate with 15% phosphoric acid.		
7	K P plat.	20 lbs. muriate of potash. 40 lbs. superphosphate.		
8	N K P plat.	20 lbs. nitrate of soda, 20 lbs. muriate of potash, 40 lbs. superphosphate.	or	40 lbs. tankage, etc. 20 lbs. muriate of potash. 40 lbs. superphosphate.
9	N P plat.	20 lbs. nitrate of soda, 40 lbs. superphosphate.	or	40 lbs. tankage, etc. 40 lbs. superphosphate.

Size of plats 1-10 acre. Upon each plat the same crop is to be grown, care being taken that the seed is pure and that each plat receives exactly the same amount of seed.

S, means stable manure; K, potash; N, nitrogen; P, phosphoric acid; O. no fertilizer.

The best arrangement is to have plats as narrow as they can be and still carry a reasonable number of rows of the crop, and, unless the field is too large, extending from one side to the other, and across all unlike strips. Such an arrangement would reduce the labor of planting and tillage to a minimum, besides securing the probable advantage of greater evenness in results.

A set of plats seventeen and one-half feet wide would carry five rows of corn or potatoes, with three and one-half feet between the rows; there would then be three rows to harvest for the measurement of the crop, the two outside rows being rejected. For cereals, as wheat, rye, barley and oats, plats as wide as could be sown with the drill, with two or three feet vacant spaces between the plats, would answer. For small fruits, plats carrying three rows should be taken, the fruit of the inner row only being harvested for the measurement of the crop.

THE PROBLEM OF IMPOVERISHED LANDS.

Part I. HOW TO UNDERSTAND THE PROBLEM.

"Some of my land will not produce a crop, although my father raised good crops on it. What shall I do to make it productive?"

This is a common type of question. It is easily asked, but very difficult to answer. The first thing to do is to find out why the land is unproductive. The remedy then follows as a natural consequence. The disease must be diagnosed, as the physicians say, before it can be cured.

If the cause of the unproductiveness is to be discovered, the land itself must be studied carefully, and the history of the field should be known. The man who is on the spot—the farmer himself—has the best opportunity to determine the cause of the trouble. One value of an education and of experiment station teachings is to help the farmer to work out his problems for himself. He can not only solve many of his problems better than the experimenters can, but he derives pleasure from the quest, and great comfort in being able to master his difficulties.

The farmer who has worn-out land must study and experiment for himself. It is the object of this bulletin to suggest how this may be done. We will specify some of the leading causes of unproductiveness, and then suggest inquiries

A. Some Reasons Why Lands Become Impoverished.

1. *They may lack tillage and good care.* It is significant that impoverised lands are usually those which have been neglected. From insufficient or improper tillage, lands become cloddy, hard, unresponsive and foul. In such cases, it may be necessary to resort to summer fallow to correct the errors,—to bring the land

back into prime condition ; but it is rare that well-farmed fields need fallowing. See Part II., paragraphs 7, 8, 9, 14, 16, 25.

2. *They may lack humus or vegetable mold*.—When in native conditions, in regions of sufficient rainfall, lands are covered with vegetation. As this vegetation dies, it becomes incorporated with the soil as humus, making the soil mellow, dark-colored and rich. It enables the soil to hold moisture, lessens extremes of temperature, hastens chemical activities, and itself supplies plant-food. When vegetable matter is withheld from the soil, the humus is not replenished, and it is gradually used up. The soil then becomes hard, "dead," very dry in dry weather and very muddy in wet weather, and is subject to great extremes of temperature. If the original basis of the soil is clay, the land bakes and becomes lumpy when plowed ; if sand, it becomes loose and leachy. See Part II., paragraphs 5, 6.

One great value of stable manure is to supply humus. Green-cropping is also exceedingly useful. A rotation of crops in which sod is one factor tends to maintain the supply of humus. Catch-crops (sown between other crops) may be used to replenish the humus; also cover-crops (those sown in fall for a winter cover). Long-continued cropping with one or with similar crops tends to deprive the soil of humus. When the farmer does not properly care for the land, nature tries to force him into another rotation. This is well illustrated in pastures and meadows, in which daisies and wild carrot force out the poor stand of grass. Most of the depleted lands in New York are suffering more for humus than for plant-food.

To determine by experiment whether a soil has sufficient humus is difficult because the forms of available humus-producing materials also contain plant-food. Humus may be supplied by muck, stable manure, leaves or green-crops. All these contain the different plant-foods, and also a large amount of vegetable matter. To test whether a soil needs humus, apply these materials to several plats of ground, leaving one or more without them for checks. Stable-manure might be applied to one plat, muck to another, a green-crop of clover, barley, buckwheat, etc., turned under on another. Nature uses leaves for making humus in the woods.

3. *They may need draining.*—Under-draining lowers the water-table (or the zone of standing water), causing the soil to become deeper and mellower. Well-drained soil is drier in wet weather and moister in dry weather than soil which is underlaid with a high and hard subsoil. Most of the cold, wet and so-called "sour" lands need draining to make them productive. Even though they are not too wet for tillage, they may need the drainage for the purpose of deepening the soil and causing it to hold more air and moisture. Deep-rooting plants, as clover, tend to make soils deeper. Subsoiling has a similar tendency, but its effect usually is not permanent. Consult Part II., paragraphs 9, page 99.

4. *The soil may become acid.*—There are some cases in which the soil becomes sour to a degree that is injurious to many plants. This is true of some sandy uplands and sometimes is indicated by growths of sorrel, daisies and golden rod. The acid in soil can be detected by its reddening blue litmus paper (to be had at drug stores or at this Station). This over-acid condition often accompanies a lack of humus, and sometimes may be corrected by adding humus. It is also relieved by the use of ashes or lime, which have the power of neutralizing or sweetening acids. The ashes or lime should not be plowed in, but harrowed in after plowing, as lime tends to work downward. When experimenting with humus (see next page), an application of ashes on an adjoining plat may help solve the problem.

5. *The soil may lack in useful plant-food.*—Some of the leading plant-food elements may be nearly or quite exhausted; or, as is more usually the case, they may be in an unavailable condition or locked up. The chemist can tell if the soil which he analyzes lacks plant-food; but another sample of soil from the same field may be very different in composition. There is very little uniform soil in New York, for nearly all of it is mixed glacial soil. But the chemist cannot tell how much of the plant-food is available to plants. Food which is nearly unavailable when he analyzes it, may be made available by a change in conditions or by better tillage; and that which is clearly available may become unavailable the same season. In certain very pronounced cases of depleted lands, the chemist may render much direct aid; but in

general he can only suggest and advise, not prescribe. The only sure way to find out whether more plant-food is needed is to experiment on the land in question.

B. How to Reclaim Depleted Lands.

1. *If you think that they lack humus, apply stable manure or turn under a green-crop.* The best general green-crop is red clover, but it does not catch well on very sandy and very hard soils. Then begin with any crop which will grow—rye, buckwheat, corn, beans, anything to get a start. If the land produces weeds when left to itself, it is good enough to produce something else. Turn the weeds under, sow something, turn it under, sow again; in two or three years the results will be seen.

2. *Till frequently and wisely.*—Many depleted lands need tillage more than humus or plant-food. Usually, they need both. Prepare the land thoroughly for the green-crop. Plow when the land is most fit. In very hard clays, try fall-plowing.

3. *If the land is so poor that it is wholly bare, determine whether it is very acid. If it is, apply lime or ashes.*—Apply some fertilizer to enable you to get a start of plants. The start once made, the future is yours. Plow under herbage; add plant-food as your experiments suggest.

We have lands which are now so completely run out that the sand drifts and no plants can obtain a foothold. It is probable that they can be reclaimed, although it is a question if the reclamation will always pay. Analyses have been made of samples of some of these lands, and it is found that they contain liberal supplies of potash and phosphoric acid, but almost no nitrogen. They are also almost wholly lacking in humus. The soils are so leachy that an application of nitrate of soda or other very soluble materials would propably be of little avail. Probably the best means of recuperating these lands is to make applications of stable manure and then to sow rye or some other cover-crop for the purpose of making a body of humus in the soil. If stable manure cannot be had, tankage will be found to be a good substitute since it contains nitrogen in a more or less insoluble form. We advise persons who have such lands to experiment with a small piece and when the experiments prove successful to extend them to a larger area. In the Old World, spurry is used to begin the reclamation of such lands. Seed can be had of the leading seedsmen.

4. *Experiment with the land to determine what plant-food it needs.*—To test the need of fertilizers, a trial of five plats may be helpful:

On the first, apply nitrate of soda at the rate of 200 lbs. per acre.

On the second, 200 lbs. superphosphate.

On the third, apply nothing.

On the fourth, 200 lbs. muriate of potash.

On the fifth, 1000 lbs. lime.

The results will in some measure indicate which of the elements of plant-food is needed.

For a more complete and conclusive method of testing fertilizers, the reader is referred to Bulletin 129. The plan of experiment, as outlined by that publication, is reprinted at the beginning of this bulletin.

Part II. A CRUSADE WITH THE FARMERS.

In the winter of 1898–9 this Station discussed a series of soil and fertility questions with the members of the Reading-Course (8605 persons). Five Reading-Lessons were issued, two of which pertained directly to soil problems; and these two Lessons are reprinted here. With each Lesson there was issued a series of questions designed to bring out the points in the Lesson. The replies which were received to these questions afford an excellent index to the state of the popular mind on subjects connected with the fertility of the land. The questions were designed to elucidate underlying truths or principles, and correct answers to them will do much towards spreading sound ideas of maintaining and increasing the productive power of the land. We therefore reprint the questions and give answers to them. These questions and answers cover all the five Lessons: "The Soil: What it is;" "Tillage and Under-Drainage: Reasons Why;" "Fertility of the Soil: What it Is;" "How the Plant Gets its Food from the Soil;" "How the Plant Gets its Food from the Air." These answers are written by H. P. Gould, but have been approved by specialists in the various subjects.

A. Reading-Lessons Nos. 1 and 2.

LESSON NO. 1 THE SOIL: WHAT IT IS.

1. *The basis of soil is fragments of rock.*—As the earth cooled, the surface solidified into rock. The processes of nature have been constantly at work in breaking up this rock and making it into soil.

2. *Weathering is the great agency in making rocks into soil.*—Rain, snow, ice, frost have worn away the mountains and deposited the fragments as soil. Probably as much material has been worn away from the Alps as still remains, and this material now forms much of the soil of Italy, Germany, France, Holland. Our own mountains and hills have worn away in like manner.

3. *Weathering is still active.*—All exposed rocks are wearing away. Stones are growing smaller. The soil is pulverized by fall plowing.

4. *The particles of soil are worn and trasported by water* —Every stream carries away great quantities of soil and deposits it in the shallows and the bays. After every rain, the streams and ponds are muddy or roily. Observe the sediment or fine mud which remains when a "mud-puddle" dries up. The rivulet may carry away tons of earth every year; and this earth is deposited somewhere, and sometime it may, perhaps, come into use again for the growing of plants. Many of our best and richest farm lands are the deposits of former streams and lakes. Such lands are fine and silt-like. Most lowlands belong to this category; and even some of our higher lands are formed from deposits from water. The mixed and varied character of soils is largely due to the fact that they are the results of transportation from different places.

Observe the flat lands about lakes. These flats are formed by the deposition of material from the surrounding highlands; but they are often exposed before their natural time by the lowering of the water level in the lakes. All lakes and ponds are filling up. Nearly every stream makes a delta at its mouth; but if the stream into which it empties is swift, the delta may be carried away.

Observe, also, the broad rounded hillocks and knolls in valleys and ravines. Many of them have attained their present form from the action of moving water.

Every farmer knows that overflowed lands are rich. He has heard of the wonderful fertility of the Nile. He should explain these facts.

5. *All productive soils also contain organic matter.*—Most organic matter is the remains of plants and animals. As found in soils in a decaying condition, it is called humus. It is the humus which gives the soil its dark or " rich " look. It also tends to make soils loose warm and mellow. It holds moisture. The addition of humus makes soils loamy. A sandy loam may be defined as a soil of which the original mineral matter is sand, and a clayey loam is one of which the basis is clay. Soils which have no humus are hard, " dead " and unproductive.

6. *Humus is supplied by means of roots and stubble, green-crops and barn manures.*—If the farmer practices a rotation of which meadow and pasture are a part, the supply of humus will be maintained. In such cases, green-manuring is unnecessary except now and then upon lands which are very hard or poor. The roots and stubble, with the droppings of the animals on the pasture, and manure applied with one of the crops in the rotation, keep the land well supplied with vegetable matter. Whenever possible, it is better to feed the crop to stock and return the manure to the land, than to plow the crop under ; for one will get back the greater part of the fertilizing value of the crops and maintain the animal at the same time. In western New York, there are hundreds of acres of refuse cabbage lands, and at this day there are thousands of tons of herbage on the ground, and no stock to eat it. It is wasteful.

Many soils which are said to be worn out are robbed of their humus rather than of their plant-food ; others have been injured in their texture by careless or faulty management. In supplying humus, it is better to add small quantities often. Lands which are under constant tillage, in corn, wheat, oats, potatoes, may be supplied with humus if catch-crops are sown with the crop, now and then, late in the season. Rye, Canada peas, crimson clover, and the like may be used for this purpose. Plow them under as soon as the land is ready in the spring, even if the plants are not large.

Observe how the forest supplies its humus. Year by year the leaves add to the soil cover, which slowly passes into vegetable mold or humus. The trunks finally decay and pass into the soil. The work is effectively done, but it consumes time ; and man is in a hurry. When the forest is removed, the land is usually productive. It is called " virgin soil," notwithstanding the fact that an enormous crop of trees has just been taken from it, and that it may have grown hundreds of such crops. The real virgin soil is the barren soil. But however rich this forest soil may be when the timber is first removed, it generally soon loses its exuberant fertility. The pigmy crops of the farmer seem to be harder on the soil than the gigantic crops of Nature. Some of this loss of productivity is due to the loss of humus.

A rotation diminishes the exhaustion of plant-food, supplies nitrogen in leguminous crops, one crop leaves the land in better condition for another, the roots and stubble improve the texture of the soil, it keeps weeds in check, provides for continuous labor because stock is kept.

The rotation should differ with the kind of soil and general style of farming. The Cornell rotation is :

Wheat,
Clover and timothy, 1 year,
Maize (corn),
Oats.

A good rotation for weed infested land is :

Sod, 1 year,
Maize,
Potatoes, or some other tilled crop,
Oats or barley.

On fruit farms, rotations are not so practicable as on grain farms ; but the fields which are not in fruit can often be worked in rotation to great advantage. The general tendency of fruit-farmers is to keep too little stock. If stock cannot be kept, the humus can be maintained by catch-crops and cover-crops.

7. *The fertility of the land is its power to produce crops. It is*

determined by three things: the texture of the soil, its richness in plant-food, and its available moisture.—The texture of the soil is its physical condition,—as to whether it is mellow, loose, leachy, cloddy, hard, and the like. A rock or a board will not raise corn, and yet it may contain an abundance of plant-food. The plant cannot get a foothold: and it would do no good to apply fertilizers. Spreading potash on a lump of clay is not farming: it is the wasting of potash. A cow will not appreciate the fanciest ration if she is uncomfortable; neither will a plant. It is only on land which is in good tilth that fertilizers pay. The better the farming, the more it will pay, as a rule, to buy plant-food: but poor farming cannot make it pay.

8. *Nature secures good texture in soil by growing plants in it.*—Roots make the soil finer, and plants supply it with humus. Plants break down the soil by sending their roots into the crevices of the particles, and the root acids dissolve some of it. Observe Nature working at this problem. First the "moss" or lichen attacks the rock; the weather cracks it and wears it away; a little soil is gathered here and there in the hollows; a fern or some other lowly plant gains a foothold; year by year, and century by century, the pocket of soil grows deeper and larger; and finally, the rock is worn away and crumbled, and is ready to support potatoes and smart-weed. Or, the rock may be hard and bare, and you cannot see any such process going on. Yet, even then, every rain washes something away from it, and the soil beneath it is constantly receiving additions. Some soils may be said to be completed: the rock is all broken down and fined. Other soils are still in process of manufacture: they are full of stones and pebbles which are slowly disintegrating and adding their substance to the soil. Did you ever see a "rotten stone"?

The longer plants are grown on any soil, and returned to it, the richer the soil becomes. But Nature has centuries at her disposal; man has but a few short years and must work rapidly, and he cannot afford to make mistakes.

9. *The texture of the soil may be improved* (1) *by underdraining*, (2) *by tilling*, (3) *by adding vegetable matter*, (4) *by adding certain materials, as lime, which tend to change the size of the soil particles.*—The reader will say that Nature does not practice tile-drain-

ing. Perhaps not; but then, she has more kinds of crops to grow than the farmer has, and if she cannot raise oaks on a certain piece of land she can put in water-lilies. We have an entire lesson devoted to drainage and tillage, and also one to manures and fertilizers. It is enough for the present to say that the roots which are left in the ground after the crop is harvested are very valuable in improving the soil. This is particularly true if they are tap-roots,—if they run deep into the soil. Clover bores holes into the soil, letting in air, draining it, warming it and bringing up its plant-food. Roberts reports ("Fertility of the Land," p. 345) that a second growth of clover, two years from seeding, gave a yield of air-dried tops of 5,417 lbs. per acre, and of air-dried roots 2,368 lbs. in the first eight inches of soil. Add to this latter figure the weight of roots below eight inches and the stubble and waste, and it is seen that the amount of herbage left on the clover field is not greatly less than that taken off. In this instance, the roots contained a greater percentage of nitrogen and phosphoric acid than the tops, and about the same percentage of potash.

Make an estimate of what proportion of the plant growth you raise is actually taken off the field. Figure up, as accurately as you can, the part left in roots, stubble, leaves, and refuse. Even of maize, you do not remove all from the field. This calculation will bring up the whole question of the kind of root-system which each sort of plant has. Have you ever made a close examination of the roots of potatoes, maize, wheat, clover, cabbages, buckwheat, strawberries, Canada thistles, or other crops? From what part of the soil do these plants secure their nourishment? What power have they of going deep for water? What proportion of them is root? Because the roots are hidden, we have neglected to examine them.

10. *The soil is plant-food; but this food becomes usable or available slowly.*—Roberts has compiled the analyses of 49 representative soils, made by American chemists, and the following is the result: "The tables reveal the fact that even the poorer soils have an abundance of plant-food for several crops; while the richer soils in some cases have sufficient for two hundred to three hundred crops of wheat or maize. The average of 34 analyses

gives to each acre of land, eight inches deep, 3,217 pounds of nitrogen, 3,936 pounds of phosphoric acid, and 17,597 pounds of potash, and this does not include that which is contained in the stones, gravel and sand of the soil which will not pass through meshes of one-fiftieth of an inch, which, by weathering and tillage, slowly give up their valuable constituents."—*Roberts*, "*Fertility of the Land*," p. 16.

Fortunately, this great store of plant-food is largely locked up, else it would have leached from the soil or have been used up long ago. By careful husbandry, a little of it is made usable year by year; and the better the management of the land the more of this food is available to the plant. When the farmer has done his best to get out of the land all that it will give him, then he may add fertilizers for bigger results.

Plant-food is available when it is in such condition that the plant can use it. It must be both soluble and in such chemical form that the plant likes it. Plant-food which is not soluble in rain water, may still be soluble in soil water (which contains acids derived from the humus); and the acid excretions from the roots may render it soluble. But solubility is not necessarily availability, for, as we have said, the materials must be in such combination that the plant will take them. Thus, nitrate of soda ($Na\ N\ O_3$) is available because it is both soluble and in the form in which the plant wants it. But nitrite of soda ($Na\ NO_2$) is not available although it is soluble,—the plant does not like nitrites.

11. *Nitrogen must probably be in the form of nitrates before it can be used by most plants.*—Nitrogen is abundant. It is approximately four-fifths of the atmosphere, and it is an important content of every plant and animal. Yet, it is the element which is most difficult to secure and to keep, and the most expensive to buy. This is because the greater part of it is not in a form to be available, and because, when it is available, it tends to leach from the soil. It is available when it is in the form of a nitrate—one part of nitrogen, three parts of oxygen, united with one part of some other element ($Na\ NO_3$, nitrate of soda; $K\ NO_3$, nitrate of potash or saltpetre; $H\ NO_3$, nitric acid, etc). The process of changing nitrogen into nitrates is called nitrification. This pro-

cess is the work of germs or microbes in the soil: and these germs work most efficiently when the soil is not water-logged, and when it is well tilled. The farmer should make his available nitrogen supply as he goes along; and he makes it with tile drains, plows, harrows and cultivators.

But there are some plants which have the power of using the nitrogen which is in the air in the soil. These are leguminous plants,—clovers, peas, beans, vetch, alfalfa. If, therefore, the farmer cannot secure sufficient nitrogen by other means, he may use these plants as green-manures. If his system of farming will not allow him to use these plants, or if he does not secure sufficient nitrogen when he does use them, then he can go to the warehouse and buy nitrogen.

12. *The soil is not a mere inert mass: it is a scene of life and activity.*—This is the new and the true teaching. Soil which is wholly inactive is unproductive. Movements of air and water, actions of heat and evaporation, life-rounds of countless microscopic organisms, decay and disintegration of plants and soil particles,—these are some of the activities of the fertile soil. If our ears were delicate enough, we could hear the shuffle of the workers, the beating of the hammers, and the roll of the tiny machinery. All things begin with the soil and at last all things come back to it. The soil is the cemetery of all the ages, and the resurrection of all life. If the soil is not idle, neither should the farmer be.

LESSON NO. 2. TILLAGE AND UNDER-DRAINAGE: REASONS WHY.

By John W. Spencer.

13. *The difference between black and white.*—Two farmers are neighbors. Mr. White has made a study of potato culture for a number of years, and, as a result, now has an average yield, one year with another, of about 200 bushels per acre from a field of three to five acres. Mr. Black is considered a fairly good farmer. as farmers go, but has given potato culture no special study. He manages his crop as his neighbors do. His methods are those which have been a tradition for several generations, and they had their origin when the country was new and high cultivation was impossible on account of the stumps and lack of tools, and also because the virgin soil made it unnecessary. His annual yield is not far from 60 bushels per acre. In other words, Mr. Black has to plow, harrow, furnish seed, plant and cultivate about ten acres to secure as many potatoes as Mr. White does from three acres. Both men sell their product to the same dealer, and we will assume that they receive the same price per bushel. The cost of producing a bushel of potatoes must be very much more with Mr. Black than it is with Mr. White. No manufacturer or merchant could withstand the keen competition in trade if handicapped as Mr. Black is. When the respective farms were reclaimed from the forest, they were considered to be alike in character of soil, and the rain falls impartially on each.

Why the difference in cost of production between Black and White? There are many points of difference in their methods, but we are free to say that one of the essential differences is in tillage.

14. *The plant needs water.*—When Mr. White contemplates a crop of potatoes, he proceeds to make an estimate of what the crop will require and how he can provide for that demand. Perhaps the greatest of all needs is water. By turning to Cor-

nell Experiment Station Bulletin 120, page 419, it will be seen that in a dry season a bushel of potatoes requires about three tons of water for its production. If Mr. White expects 200 bushels of potatoes per acre, he must somehow manage to provide 600 tons of water for each acre. He has no facilities for irrigation, and his only resource is to make the soil a reservoir. He must store the supply left by winter snows and spring rains, and also the irregular rainfall that comes during the season's growth. Speaking in broad averages, in soils most commonly met with, this storage possibility amounts to about 300 tons of water per acre in the first eight inches of the soil. It must be understood that this amount is not in the form of standing water, for water standing in the soil for any length of time injures both soil and plant.

15. *The most useful form of water for plants is film moisture.*— Water is capable of assuming many forms, such as steam, vapor, ice, or free-moving liquid. The condition most valuable in the soil is none of these, but is in the form of film moisture. This film moisture can be shown by dipping a marble into water and observing the film of water surrounding it on all sides. When each soil-grain is covered with film moisture, as the marble is, the ideal conditions of soil moisture exist. This form of water is largely independent of gravitation and travels readily in all directions, as can be seen by dipping a cube of sugar into a spoonful of coffee. It is capable of transporting plant-food to the roots of plants from remote corners, where the roots do not reach.

It will be observed that film moisture is held only on the surface of soil-grains. The more the soil is pulverized, the more soil-grains there will be, and therefore the greater amount of surface to hold film moisture.

The difference in the capacity of lumpy and fine soils to hold film moisture is surprising to one who has not given the question study. George W. Cavanaugh, assistant chemist at the Cornell Experiment Station, has very graphically shown this by the following experiment: He put small marbles in a tumbler, as shown by Fig. 22, and the total amount of film moisture that the marbles would carry is represented in the tube placed beside the tumbler. The soil in the other tumbler (Fig. 23) is of the same weight as the marbles in Fig. 22, and it represents the marbles reduced to the fineness of common sand. Its capacity for holding film moisture is represented by the water in the standing tube (Fig. 23). The weight of material is the same in each tumbler, and the reason why one holds three times more film moisture than the other is due to the increase of surface that comes by dividing a coarse lump into fine particles.

The marbles represent the careless tillage of Mr. Black, and the finer particles the thorough tillage of Mr. White. Mr. White plows about one-third deeper than Mr. Black, and thereby makes another addition to the capacity of his reservoir.

The coarse soil, as represented by the marbles, will lose its film moisture by evaporation much more readily than the soil represented by Fig. 23, particularly if the surface of the latter is covered by fine particles representing an earth-mulch.

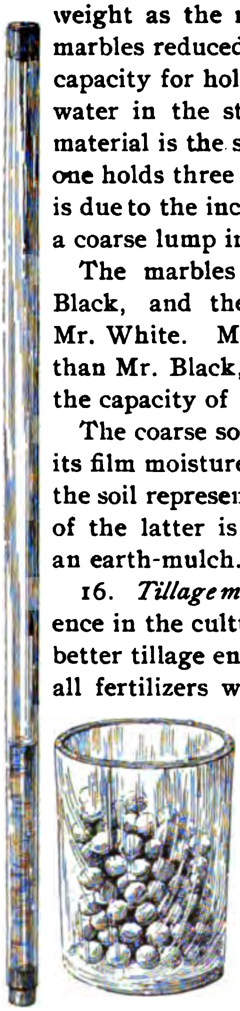

FIG. 22.—*Water held by a coarse soil.*

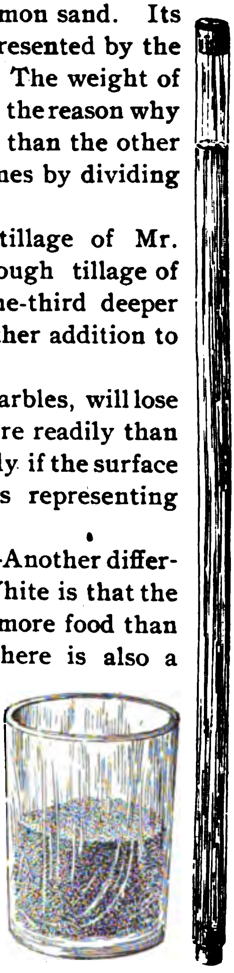

FIG. 23.—*Water held by a fine soil.*

16. *Tillage makes plant-food available.*—Another difference in the culture given by Black and White is that the better tillage enables the plant to realize more food than all fertilizers which may be applied. There is also a benefit in making available some of the plant-food that nature has put in the soil. Broadly stated, the native plant-food amounts to as much as can be bought in $2,000 worth of commercial fertilizers. The finer soil has another advantage in affording a greater area for root pasturage. It is not uncommon for farmers to think of plant-food in the soil as in the condition of salt or sugar which is capable of being immediately dissolved by water and at once appropriated by

the plant, or like potash in ashes that can be soaked out. Plant-food exists in this form only to a limited extent. A man might famish if locked in a granary filled with wheat; yet a chemist would say that there was enough food near him to feed a hundred men. This illustrates how nature has stored much of the plant-food in the soil. It has to go through many changes before it can be appropriated by the plant. The soil is a factory in which the work of preparation is carried on.

17. *The soil is a laboratory.*—Some of the agents employed in this factory are film moisture, air and heat; and if these are not furnished in the proper extent and condition, the factory runs in a sluggish way, if it does not stop altogether. Good tillage does much to hasten the activities of this factory by allowing free ingress to the soil of film moisture, air and heat. Air is necessary for a supply of oxygen, and heat to facilitate fermentation and other vital processes.

The importance of air and heat in the soil brings us to the question of drainage. Air cannot enter a soil freely which is filled with standing water, and growth of micro-organisms is hindered.

18. *Wet soils are cold.*—Standing water is a great absorbent of heat. If no provision is made to drain it away, it must be evaporated away. Thereby heat is lost. The soil is cold. A great many barrels of water can be standing on an acre of ground and not attract much attention.

To appreciate the amount of heat necessary to evaporate water, one has only to chop, split and burn beneath a caldron kettle enough wood to evaporate a barrel of water. Every barrel that is evaporated from the soil by the sun absorbs as much heat as is expended by the wood used under the kettle. The soil and plants are perhaps chilled for want of that heat. This is the reason that a wet soil is said to be cold.

19. *Drained soils resist drought.*—Some farmers have the notion that well drained soil will not withstand a drought as well as an undrained soil. The contrary is true. Everyone who has tilled the soil is familiar with places that are wettest in a wet time and driest in a dry time. When these places dry at all, they dry like a brick. A wet soil can never be tilled so as to present

the greatest amount of surface for film moisture and give it a mellow texture to receive a gentle saturation of air ; and standing water robs it of much heat required by the soil and plants.

20. *Drainage makes a soil reservoir.*—There is a place in every soil at which the free water stands. This place is called the water-table. It may be three inches down, or a hundred feet. It is the bottom of the soil reservoir, the bottom of our dish-pan. This dish-pan, or the upper and tillable soil, is the reservoir. It is the part in which the water is held as films on the soil particles. These films travel from particle to particle, the general tendency being upward because the moisture is passing off near the top of the soil by means of evaporation and appropriation by plants. Moisture is constantly supplied from the water-table below. We speak of this movement as capillary attraction.

Under-drainage lowers the water-table. It lowers the bottom of the dish-pan ; and thereby there is a deeper reservoir above it for the holding of film moisture and the distribution of roots.

But, the reader says, if the water-table supplies moisture to the upper soil, then it must be useful and necessary. Certainly ; but it must not be too high, for roots of farm plants do not thrive in standing water. If the upper soil is well tilled, capillary attraction will bring the moisture up.

21. *Do not let the moisture get away.*—We want this film moisture in the upper soil in order that roots may use it. The plants do not use it, to any extent, after it has passed off into the atmosphere. Therefore, stop this water before it reaches the atmosphere.

How ? Put a layer of loose dry earth between the moist soil and the atmosphere. This layer will stop the upward capillary flow. This layer is the earth-mulch. It conserves, or saves, moisture.

22. *Dry and hard soils way be benefitted by under-drainage.*—The water-table is lowered. Air is admitted. The soil does not puddle. It becomes fine. Under-drainage makes wet soils dry by removing the free water ; it tends to make dry soils moist by deepening the reservoir and fining the particles of soil.

23. *What tillage tools are for.*—Some tools, as plows, are to mellow up the soil and to deepen the moisture reservoir.

Others, as cultivators, are to tear up and to pulverize the soil to greater or less depths. Cultivators lift and turn the soil. The spring-tooth harrow is really a cultivator. Other tools, as harrows, prepare the surface of the soil. They make the seed-bed and put on the earth-mulch. The true harrows stir the soil, but do not lift or invert it.

24. *Weeds do not presist in well-tilled lands.*—The first and greatest value of tillage is to put the soil in such condition that plants can grow, and then to keep it so. Incidentally, it prevents those plants from growing which we do not want,—the weeds. Usually, the process is reversed: weeds make us till, and we get the other benefits without knowing it. The best tillage prevents weeds rather than kills them.

25. *Summer-fallowing is a means of cleaning land and of correcting mistakes.*—It may be necessary to fallow the land in order to clear it of stones, stumps and brush. But after the land is once thoroughly subdued, summer-fallowing is very rarely necessary if the land has been well handled. If the land has been plowed when too wet and thereby has become lumpy, if it has been allowed to become foul with weeds, or if it has lost heart by too continuous cropping with one kind of crop, summer-fallowing is a good means of bringing it back into condition. The better the farming, the less the necessity of summer-fallowing. In the old days, the poor tillage tools rendered fallowing more necessary than it is to-day.

Fallowing is tillage; and tillage liberates plant-food. Some of this plant-food may leach away and be lost, although the small rainfall of the summer months,—during which time fallowing is practiced,—makes this loss slight.

26. *The kind of tillage should vary with the soil, the time of year, the kind of crop.*—Too many farmers seem to think that tillage is tillage, no matter how it is performed. The same tool is used for clay or sand or muck, and for fitting the land for wheat or corn or apple trees. A harrow that is best for one field may be worst for the adjoining field. A man would not think of using a buggy for carrying grain to market, but he will use one tool for many kinds of work. The work is not only poorly done, but it is not economical. It costs too much. Persons who will

economize to the smallest degree in expenditures of money may be very wasteful in expenditures of labor and muscle.

Persons are always asking if deep plowing is best. The question cannot be answered on general principles. Deep plowing may be best for one field and one crop, and shallow plowing best for another field and another crop. The same remarks will apply to fall-plowing and spring plowing. One must first learn principles, or the why; then the practice, or the how, will come easy.

NOTE. The reader should have other sources of information than this Lesson. He may read our Bulletins 119, "Texture of the Soil;" 120, "The Moisture in the Soil;" 72, "The Cultivation of Orchards;" and the three bulletins on potato culture (Nos. 130, 140, 156). His library should also have King's "Soil" and Robert's "Fertility of the Land."

B. Answers to the Questions on the Five Lessons.

NO. 1. THE SOIL: WHAT IT IS.

Many of the questions in this lesson are intended merely to call attention to certain fundamental facts and to promote thought and discussion.

1. *Have you ever observed the influence of weather upon soft slaty rock jutting out on embankments and in railroad cuts?*

2. *Have you ever taken a glass of muddy water from a flowing stream and allowed it to stand until the sediment had settled? What is this sediment?*

These questions are intended merely to call attention to this process of soil formation and transformation.

3. *Imagine a branch of this stream bringing rotted slate rock and another bringing fine sand. When mixed in the main stream and deposited on some bar or overflowed field, what kind of soil would the mixture make?*

A sandy or clayey soil, the exact nature of which would be governed by the relative proportion of the different ingredients. Such a mixture might also contain much decaying vegetable or organic matter, and this would make the physical condition of the soil such that it would be very fertile.

4. *What is inorganic matter?*

All matter which is not a part or product of a living organism is inorganic or mineral matter, as a stone or a piece of iron. The bulk of the soil is made up of finely pulverized stone and is therefore inorganic matter.

5. *What is organic matter?*

Matter which has life or has been produced by living organisms. An animal or a tree, either living or dead, is organic matter. The humus of the soil is decaying organic matter.

6. *Why are soils from which a thrifty forest growth has been removed capable at once of producing good farm crops?*

Largely because of their good physical condition, due chiefly to the presence of large quantities of humus.

7. *Have you ever observed lichen (sometimes called "moss") growing on bare rock or on a tombstone?*

This question is intended to call attention to the fact that low forms of plant life are important in the early stages of soil formation.

8. *If any great amount of lichen should become mixed with the disintegrated rock, would it be humus and form a weak soil that might produce an order of plants a little larger and stronger than lichen?*

This mixing of the moss with the pulverized rock would be the first step toward making a soil of good physical qualities.

9. *As the higher orders of plants come in and die down and mix with the soil, would the process increase the productive power of the soil?*

Yes, within certain limits. The more decaying vegetable matter the soil contains, generally the more productive it is.

10. *In instances in which soil has been removed by grading, could a new soil be well made by adding commercial fertilizer alone? What would you apply first to such land?*

The addition of humus would be of first importance. Commercial fertilizers would do little good applied to a soil in which there is no decaying vegetable matter. This would propably be the condition in the case assumed in the question.

11. *If humus in soil under cultivation is perishable, ought it not to be the farmer's first care to keep good the quantity first found in the virgin soil?*

Yes; and this can be done only by adding humus from time to time in the shape of barn-yard manure and other forms of organic matter.

12. *In addition to the humus returned to the soil in manure, from forage fed to stock, and by plowing under stubble and roots, do you think it a good plan to sow some cover-crop in corn rows at last cultivation, and on oat and wheat stubble as soon as the crop is off, for plowing under the following spring?*

Usually a cover-crop is desirable, and especially so if the soil is lacking in humus.

13. *What are good crops for this purpose?*

Crimson clover, vetch, peas, rye, rape, barley, oats.

14. *Which of these are leguminous plants? Name all the kinds of leguminous plants you know?*

The first three named. All the clovers, alfalfa, vetch, peas, beans, lupines.

15. *Why is it advised to plow under the green-crops as soon as the land can be worked in the spring?*

These crops, if allowed to grow, would give off into the air much moisture needed by the permanent crop; and besides this, if left until they had made a large growth, there might not be enough moisture in the soil to cause them to decay.

16. *Do you think a rotation of crops helps the soil to bear the strain of successive cropping? If so, why?*

Yes: this practice admits of supplying humus by means of cover-crops; it admits of tillage which sets free plant-food; and as different kinds of plants require different proportions of the various plant-foods a rotation prevents an unequal depletion of plant-food, as might be the case if one kind of crop was grown continuously for a long time.

17. *Are you aware that plant-food exists in the soil in both available and unavailable forms, and that when plants have used up most of the available portion we call the soil worn out?*

Most soils, even though unproductive, contain plant-food in large quantities, but it is in such condition or chemical form that plants cannot get it.

18. *Is it true that your soil is capable of being made an active laboratory in which changes will take place and some of this unavailable plant-food be made usable?*

It is only when the soil is in such condition that certain changes can take place, that the unavailable plant-food becomes available to the plant.

19. *Are you aware that when the texture of your soil is poor, or in other words, your laboratory is out of order, the best commercial fertilizers or stable manures will not give the best results?*

The texture or physical condition of the soil is of first importance. A stone contains plant-food, but it will not grow crops because of its physical and chemical condition.

20. *Do you know that heat and air are important agencies in the changes going on in the soil, as they also are in the changes in a barrel of cider or in yeast in a pan of dough?*

Chemical changes in the soil cannot take place to the best advantage when the air is excluded, or when certain definite temperature cannot be maintained.

21. *Does standing water on soil have a detrimental or beneficial effect on the heat and air? Why?*

Detrimental, because it keeps the temperature too low and excludes the air; and soil texture is impaired.

22. *How can you make the soil laboratory do the best work?*

By making and preserving the best physical condition possible.

NO. 2. TILLAGE AND UNDER-DRAINAGE: REASONS WHY.

1. *What proportion of farmers in your neighborhood farm it like Mr. Black?*

Apply the test to yourself, and see if you are using good, economical business methods in carrying on your farm.

2. *How is farming to be made to pay,—by getting higher prices or by cheapening cost of production?*

Prices are largely beyond our control; the cost of production very largely rests with us. At least, this is true within certain limits.

3. *Do you expect permanently higher prices for farm produce?*

The past may be taken as a reasonably fair indication of the future.

4. *Do you set a certain yield before your mind when yov are preparing for a crop? Or do you expect to be content with what comes?*

In the first case, you are farming with your head as well as with your hands, and the aim is to control circumstances as much as possible: the work is done on a good business basis. In the latter case, you are allowing yourself to be ruled entirely by circumstances and your work is not conducted in a good business-like manner. The same careful, judicious business management is necessary in farming that is needful in a successful commercial enterprise.

5. *An inch of rainfull weighs about 113 tons to the acre. About 300 tons of water is required to produce one ton of dry matter. Do you have rainfall enough in June, July and August to maintain a heavy crop of Indian corn or cabbage?*

In considering this question one must keep in mind the fact that much of the rain-fall drains off into streams, especially on hilly land; also that large quantities are evaporated before the plants can take it up. On account of these losses only a part of the rain is available for the plants. Usually the rainfall in midsummer is not sufficient to maintain a heavy crop, and so we must try to save, by thorough cultivation, what fell earlier in the season.

6. *Does surface tillage make soil moist, or keep it moist?*

It keeps it moist by preventing the soil from drying out. When soil is left undisturbed for a long time, and it becomes packed down, the moisture in the soil works toward the surface and is evaporated, passing off into the air. Tillage makes a surface mulch which the soil moisture cannot readily pass through. It is equivalent to covering the soil with a layer of straw or a board. Every farmer knows how moist it is under a pile of straw which has remained in the same place for some time, or under a board. This straw or board does not make the soil moist but prevents it from becoming dry. This is what tillage does.

7. *Why does deep fall plowing make soils "warm" or "early" in spring?*

Land so treated tends to dry out earlier in the spring than unplowed soils; and soils which dry out early in the spring are "warm" and consequently "early."

8. *What proportion of farmers in your vicinity practice underdrainage?*

The important point to be considered is, Does your farm need under-draining?

9. *How many of the farms need under-drainage?*

There is comparatively little land which will not be improved by under-draining.

10. *How deep and how far apart would you lay under-drains?*

The distance apart should be governed in a measure by the depth: the deeper the drains, the farther apart they may be placed. The contour of the land and the nature of the soil will also influence very materially in the matter. In a general way we may say that in moderately porous soils drains three feet deep should be from 30 to 40 feet apart.

11. *Do the farmers of your neighborhood have enough different kinds of tools to enable them to till their land cheaply and efficiently?*

This will depend upon the nature of the soil and the kind of crops grown. It is a good question to think about.

12. *How many different kinds of tillage tools should a man have to farm it properly if he has 100 acres devoted to general farming, of which half is clay and half sandy soil?*

This question is too general to admit of any one fixed answer. Each farm differs in some respects from every other, and the tools used on the one farm probably would not be exactly suitable in all details for another farm. Let each man answer.

13. *How often would you till a field of corn or potatoes?*

Often enough to keep the soil-mulch in good condition,—that is, light and loose. Study this question.

14. *Why do you till your corn or potatoes? Are weeds the leading problem in your mind?*

The keeping of the soil-mulch light and loose should be the leading idea. When this is done, few if any weeds can grow.

NO. 3. FERTILITY OF THE SOIL: WHAT IT IS.

1. *Do plants obtain all their food from the soil?*

A part comes from the soil and a part from the air.

2. *What do you mean when you say that soil is exhausted,—that it has no more plant-food in it, or merely that it fails to produce crops?*

When a soil merely fails to produce a crop, it is usually said to be exhausted, regardless of the amount of plant-food which it may contain.

3. *May a soil fail to produce crops and yet not be exhausted of plant-food?*

Yes; the plant-food must not only be present but it must be in such a form that the plants can use it. The physical condition of the soil also has much to do with the size of the crop. A soil which is hard and lumpy, containing an insufficient amount of humus, will not produce a good crop, even though it contains an abundance of plant-food.

4. *If there are 13 plant-foods which are positively essential, why do we commonly speak of only 3 of them as plant-foods—of nitrogen, potash, phosphoric acid?*

All the other plant-foods are sufficiently abundant in an available form in most soils, so that they do not have to be considered in maintaining the fertility of the land.

5. *Do you know if there is any difference between phosphorus and phosphoric acid? Write the chemical symbol for each.*

Phosphoric acid is a certain amount of phosphorus plus a certain quantity of oxygen. The symbol for phosphorus is P; for phosphoric acid, P_2O_5.

6. *Is there any difference between potassium and potash? Write chemical symbols for each.*

Potash is potassium plus oxygen, combined in a certain definite proportion. K stands for potassium; K_2O for potash.

7. *Write the chemical symbols for calcium and lime.*

Ca is the symbol for calcium; CaO stands for lime.

8. *Where do phosphorus, potassium and calcium come from,—from the ground or from the air? Are they gases or solids?*

They come from the ground. They are solids.

9. *Where does oxygen come from?*

It comes from the air; about one-fifth of the air is oxygen and four-fifths nitrogen.

10. *Do you know if phosphorus, potassium and calcium exist in nature in their pure state?*

In nature they exist only as compounds with other substances.

11. *Does oxygen exist anywhere in a pure or uncombined state?*

Yes; oxygen exists in the free or uncombined state in the atmosphere. About one-fifth of the atmosphere is oxygen.

12. *Of what is water composed? Write its chemical formula.*

Of hydrogen and oxygen; the symbol or formula is H_2O.

13 *Of what is ammonia composed? Is it a gas or liquid? Can you buy pure ammonia at the drug store?*

It is composed of nitrogen and hydrogen (NH_3). It is a gas. Ammonia of the drug stores is water which has absorbed some of the ammonia gas.

14. *Does the plant feed on ammonia directly?*

Very little if at all. It must first be changed to a nitrate.

15. *What is the composition of a nitrate? Write the formula for nitrate of potash and nitrate of lime.*

Nitrates are the result of treating substances with nitric acid. For nitrate of potash it is KNO_3; for nitrate of lime, $Ca(NO_3)_2$.

16. *In what kind of materials does nitrogen occur? Name some common things which you think contain nitrogen.*

Nitrogen occurs in organic materials, as in plants and animals. In meat, leather, hair, milk, humus of the soil, cotton-seed meal, etc.

17 *Is nitrogen a solid or a gas?*

It is a gas.

18. *Are nitrates of potash and soda solids, liquids or gases?*

They are solids.

19. *Are nitrates soluble? Is there danger of their being lost from the soil?*

Yes. Loss is likely to occur, especially on land which remains for a long time with no crop on it.

20. *What is an amendment?*

A substance which, while it has little or no value as a plant-food itself, acts in such a manner as to make plant-food already in the soil more available, or which improves its texture.

21. *Is the soil in your garden sour? Try it.*

See Reading-Lesson No. 3, page 7.

22. *In what materials can you buy phosphoric acid for fertilizer purposes?*

The most common materials are forms of bone. South Carolina rock and Florida rock are ancient deposits of fossilized bone. Ground fresh bones are sometimes used as a source of phosphoric acid.

23. *In what can you buy potash?*

The common commercial forms of potash are sulfate of potash and muriate of potash. Wood ashes is also a source of this plant-food.

24. *In what can you buy nitrogen?*

Sulfate of ammonia and nitrate of soda are common forms. Cotton-seed meal, dried blood and tankage are some of the organic sources.

25. *Are there any home fertilizers, or common farm materials (aside from barn manure), in which you can get these elements?*

The plowing under of green-crops, like clover, peas, vetch and the like will furnish nitrogen ; wood ashes furnish the only "home supply" of potash ; phosphoric acid must usually be purchased from the dealers.

NO. 4. HOW THE PLANT GETS ITS FOOD FROM THE SOIL.

1. *Do the root-hairs finally become roots, or do they stay on as the main root grows?*

The root-hairs never become roots. As the young rootlets which bear the root-hairs enlarge and their tissues become hard, the root-hairs perish.

2. *Are there root-hairs on old roots?*

No.

3. *On what part of the roots are the root-hairs?*

On the young, tender rootlets.

4. *Where does the radish plant, which you grew in moss or cloth, get nourishment for making the first root-hairs?*

This nourishment probably comes from the food-material stored up in the seed.

5. *Why do particles of soil adhere to a young plant of wheat or cabbage when it is pulled up?*

Because the root hairs and rootlets are so numerous and in such close contact with the soil. The finer the soil, the closer and more extensive this contact is.

6. *What do you understand by a solution?*

A substance dissolved in a liquid.

7. *Give an example of a substance which will dissolve in water, and one which will not.*

Sugar will dissolve; sand will not.

8. *May materials which are insoluble in rain water be soluble in soil water? Why? (Consult Less. 3.)*

Yes. Because the soil water contains carbonic acid gas in solution and this increases the dissolving power of water.

9. *Does warming the water increase its power to make substances soluble?*

Yes.

10. *Write a definition of osmosis. (Consult dictionary or some school book on physics or natural philosophy.)*

It is the tendency of two liquids of different density to pass through a membrane or porous wall which separates them.

11. *Why does the soil water go into the root-hair?*

It is largely on account of this osmotic tendency or action. The outer walls of the little root-hairs constitute the membrane; the sap or moisture in the cells of the root-hairs and the soil-moisture represent the two liquids separated by the membrane. (See Reading-Lesson 4, fig. 3.)

12 *Why does not the liquid in the root hair flow out into the soil?*

Because the sap in the hairs is denser than the water or moisture in the soil; that is, it contains a larger percentage of solid matter in solution. When two liquids of different density are separated by a membrane, the passage of the liquid through the membrane is in the direction from the less dense to the more dense.

13. *What would happen if the liquid in the root-hair and that in the surrounding soil were of equal density?*

There would be little or no movement of the water from the soil into the root-hairs and the plants would die.

14. *Must all food materials in the soil be in solution before the plant can use them?*

Yes.

15. *Does the plant ever utilize materials which are insoluble in the soil water? How?*

Yes; the roots of plants are slightly acid and this increases the dissolving power of the moisture in contact with the roots.

16. *How is it that plants can live and grow in a soil which dust dry?*

Even the soil which seems to us dust dry really contains very minute amounts of water; and so long as this is the case osmotic action goes on though, of course, very slowly when the soil is "dust dry."

17. *Can your soil be so loose as to have too much air for the good of the plants?*

Yes. This is sometimes the case in very light sandy or gravelly soils.

18. *Do you understand that you can smother the root as well as the top of the plant? How?*

Yes. The roots need air as well as the top. Soil which is constantly soaked with water prevents the air from coming in contact with the roots; smothering results as one of the effects of too wet land.

19. *At what season do you suppose that corn roots absorb the most moisture?*

When the corn is making its most rapid growth.

20. *At what season do you have the least rainfall?*

During the summer season when plants are growing most rapidly.

21. *If you knew that you would not have sufficient rainfall in August to maintain your potato crop, how would you plan to secure the moisture?*

Prevent evaporation so far as possible by means of a surface mulch. This means thorough tillage.

22. *Name one way in which plants are injured by too strong dressings of potash or nitrogen.*

If applied in such large quantities that the soil moisture dissolved larger proportions than were contained in the sap—that is, if the density of the soil moisture became greater than of the sap—osmotic action would be from the plants to the soil and the plants thus giving up their moisture to the soil, would wilt.

23. *If all the potash in your cornfield were to become suddenly available, what would happen?*

The corn would be killed and heavy rains might leach much of the potash from the soil.

24. *How might you apply muriate of potash so that strawberry plants would be injured?*

By applying in large quantities too close to the plants.

25. *Would it be an easy matter to injure old apple trees by muriate of potash? Why?*

If applied in very large amounts directly over the roots, injury might follow; but such injury is rare.

26. *If you put the fertilizer in the hill, will not the roots grow beyond and away from it, as the plant grows?*

Yes, to a large degree.

NO. 5. HOW THE PLANT GETS ITS FOOD FROM THE AIR.

1. *What proportion of its dry substance does the plant secure from the soil?*

The amount is variable, but on an average about 3 per cent. Some varieties of plants take up much more and others less than 3 per cent.

2. *What one substance or compound is taken in most profusely by the plant?*

Water.

3. *How does the plant get its water,—through roots or leaves?*

Through the roots.

4. *In what part of the plant does the water ascend,—through the young wood, or between the bark and wood?*

It ascends through the young wood.

5. *Where does the plant get its carbon?*

From the air.

6. *How does it take in its nitrogen,—by roots or leaves?*

By the roots.

7. *Where is the starch manufactured?*

In the leaves and other green parts.

8. *From what substances is the starch made?*

From carbon dioxide and water.

9. *Of what elements is starch composed?*

Of carbon, hydrogen and oxygen.

10. *Into what is the starch changed before it is transported?*

It is changed into sugar.

11. *What use is made of the material after it is transported?*

It is used in the growth of the plant.

12. *Through what part of the plant does the starch-like material (or "elaborated sap") pass?*

It diffuses through the layers of the inner bark.

13. *The root takes in water containing food: Can it use this food material directly in making root-growth? Why?*

No. This food material is taken into the plant in a crude condition, and it must be transported to the leaves where it unites with other materials before it can be used in the growth of the plant.

14. *Why is starch stored in seeds and tubers?*

To be used by the seedlings or new plants when growth first begins, and before the plants are sufficiently developed to take their food from the soil and air.

15. *Is starch stored in twigs in the fall?*

Yes.

16. *Are the flowers of peaches, and other early blooming plants, fed from food taken in at the root at the time, or from materials stored in the twig? (Think how the potatoes sprout in the bin.)*

From materials stored in the twigs the year before. It is for this reason that the condition and health of the trees this year influence so largely the crop of next year.

17. *Will mulching the roots of a peach tree with straw when the ground is frozen delay the blooming in the spring?*

No; because there is food enough in the twigs to feed the blossoms, and as soon as the weather is warm enough this food is available.

18. *Soil water holds very little food for plants: the roots must take in enormous quantities of water: what becomes of some of this water?*

It passes off through the leaves.

19. *Is the water which evaporates from the soil of any direct use to the plant?*

No, not of itself.

20. *The plant needs water,—it sweats it out: how shall we manage so that the plant can have all the water it needs?*

An abundance of water goes into the soil (in New York) every year, but it is not equally distributed. When the plants need it most is the time when there is usually the least rain. The only way we can help the plants (unless we irrigate) is to preserve the moisture so that it becomes available when it is most needed. This may be done by draining the land, and in this way increase the storage capacity of the soil (See Lesson No. 2); and by keeping a good earth-mulch on the surface so as to prevent, as much as possible, the evaporation of the water from the soil.

21. *Write down all the substances (or materials) you know which the plant must have in order to live and grow.*

Nitrogen, phosphorus, potash, lime, iron and sulfur were given in Lesson No. 3 as some of the necessary plant-foods. Carbon, hydrogen and oxygen are also necessary.

22. *Which one of these does nature supply in sufficient abundance, without any thought on your part?*

Carbon.

23. *What ones can you help nature to supply?*

Nitrogen, potash, phosphoric acid, lime and water.

24. *Name all the congenial conditions (or agencies) which the plant must have in order to be comfortable and to grow.*

A certain temperature; a certain water supply; a certain amount of humus; good texture; and a sufficient supply of plant-food.

25. *What ones of these can you help nature to supply or maintain?*

We can influence the water supply, add plant-food and humus, and maintain good texture.

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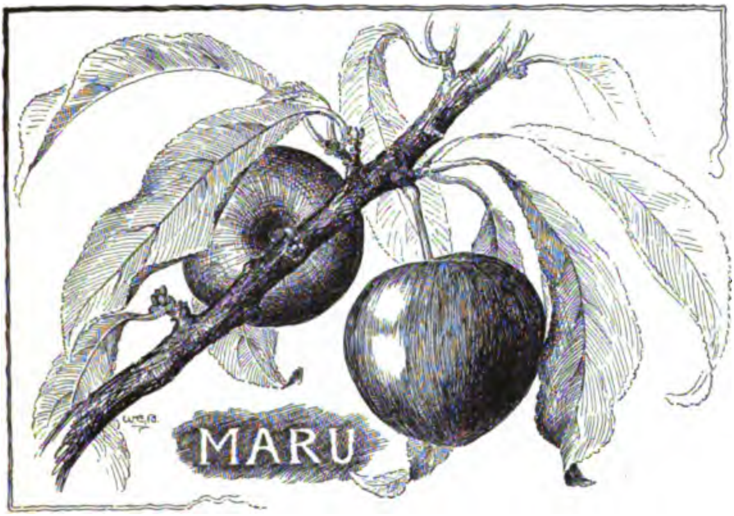
Bulletin 175. **November, 1899.**

Cornell University Agricultural Experiment Station,
ITHACA, N. Y.
HORTICULTURAL DIVISION.

FOURTH REPORT ON

JAPANESE PLUMS.



By L. H. BAILEY.

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CORNELL UNIVERSITY, ITHACA, N. Y., NOV. 1, 1899.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The Japanese plums have come to stay, but they have come without accurate descriptions and with confused nomenclature. The merits of the older varieties are now fairly well known, but the greater number of the varieties are very imperfectly understood. In order to elucidate these perplexities and to spread accurate knowledge of this new class of fruits, the Cornell Station has made a special effort to study all the varieties from bearing trees. This bulletin is the fourth report of this investigation.

I. P. ROBERTS, Director.

24.—*Earliest of All* (*on left*) *and Engre. The earliest Japanese plums.*

FOURTH REPORT ON JAPANESE PLUMS.

In January, 1894, this Station issued a bulletin (No. 62) on the Japanese plums. Subsequent issues were made in January, 1896, and in October, 1897 (Bulletins 106, 139). For five years and more, the Japanese plums have been the subject of careful study at Cornell, and an effort has been made to secure all the varieties. During the past season the crop of these plums has been large and excellent, and the following notes are made directly from the fruits. We are still convinced that the Japanese plums are a very important addition to our orchard fruits. They will not drive other plums from the field, but they have attributes which make them an excellent supplement to the European and native sorts. The particular merits of the Japanese plums are their great productiveness, adaptation to a wide range of territory, beauty, earliness of many of the varieties, comparative freedom from diseases and insects, and long-keeping qualities of fruit. Most of the varieties tend to overbear, and good fruits can be secured only by very heavy thinning. This is especially true of the Burbank, the Abundance and the Red June. There is great range in quality of the Japanese plums. The poorest of them are inferior to any of the European varieties. The best of them are nearly equal to the best of the European kinds, and all of the leading sorts are better in quality than the Lombard if they are properly thinned and ripened.

A great merit of the Japanese plum is the fact that it is adapted to an exceedingly wide range of territory, in this respect excelling both the Domestica and native types. There are varieties which thrive from Canada to the southern States, and apparently from ocean to ocean. There has been some complaint in the Middle states and the South of loss of blossoms from late spring frosts, but we have never experienced this difficulty. The buds start early; but in New York State, at least, the winter climate holds so late that there is practically no danger from the early swelling of the buds.

The Japanese plums are less seriously attacked by insects and fungi than the common European or Domestica type is. They are not entirely free from the shot-hole fungus, black-knot, curculio and other difficulties; but in our experience these troubles have been so infrequent or of such minor importance as not to attract serious attention. The fruit-rot is often serious on the Japanese plums; but in our experience, it is equally or even more serious on the Lombard. If the Japanese plums are properly thinned, there seems to be no unusual susceptibility to the fruit-rot fungus.

The larger part of the Japanese plum stock which is sold by nurserymen is on peach roots: and on these roots they seem to thrive. However, we find that they do remarkably well when top-worked on Lombard stocks. Theoretically, we are to expect the best results when they are worked on their own roots; and these plums are now so extensively planted that the time cannot be far distant when seed can be obtained cheaply enough to warrant the raising of Japanese plum stocks. It remains to be demonstrated, however, whether the Japanese plum roots are actually better than the peach or the Domestica plum roots.

In former reports, we have spoken of the great variation of Japanese plums in respect to the period of ripening. We find that the same trees often do not ripen their fruit in the same sequence in different years. In some years there may be a difference of two weeks in ripening between the Abundance and Burbank, whereas in other years the very same trees may ripen their fruit almost simultaneously. The period and sequence of all fruits are greatly modified by the particular season, but the Japanese plums seem to be particularly unstable in these respects.

Ever since we began the study of these Japanese plums, we have been puzzled to account for the great differences in opinion respecting the merits of individual varieties and the wide discrepancies in descriptions of them. Some of these discrepancies are traceable to a confused nomenclature; but we now believe that many of them are due to the fact that the same tree may bear unlike fruit in different years. Some of the trees which we have had under the closest observation during two or three crops seem to have behaved in this way. For example, in our last report (Bulletin 139) we thought that the Chase is identical with the Chabot. This year, however, the fruit of the same trees of Chase was indistinguishable from Abundance; and yet, between Abundance and Chabot there is normally a difference of two to three weeks in the period of ripening, and there was this difference on our own grounds this year. From this year's study, therefore, we are obliged to say that the Chase is the Abundance.

Some objection has been raised to the supplanting of Japanese names with new names. We are convinced, however, that the dropping of the Japanese class-names and adjectives is legitimate in the interest of perspicuity. Most of the Japanese names have been loosely applied, and it is impossible, in many cases, to determine any one variety to which the name may be said to belong. To use the old name of Botan, for example, would result in perpetuating a confusion, since any person who had a plum under the name of Botan, no matter what it was, would feel justified in sending it out. When, however, the different kinds of Botans are given specific names, the person must distinguish his variety before it can be put upon the market. The same remarks may be made for the Japanese names, Hattankio, Yosobe, Sumomo and Wassu. (Wassu is probably a misspelling of Wasse, or Wase, meaning *early*). There are two or three Japanese names, of which Maru and Satsuma are examples, which have been applied to one particular variety; and in these cases we have held to the Japanese vernacular.

It is usually unsafe to make a general recommendation of varieties of any fruit. The value of a variety lies not only in its intrinsic merits, but in its adaptation to the personal likes of the grower and to markets, soils, and other extrinsic conditions. However, as a guide in the choice of varieties, I will mention those kinds which now seem to me to be most valuable for general uses and conditions. In the first list I place those which seem to be worthy of general planting; in the other list are those of secondary value and those which must be further tested before they can be confidently recommended. The varieties are named in the order in which they ripened at Ithaca in 1899:

First list.

Engre
Lutts
Red June
Abundance
Burbank
Chabot
Satsuma

Second list.

Berger
Kerr
Ogon
Georgeson
Hunn
Hale
Wickson

In the following account of varieties, we record the notes which have been taken on the Cornell grounds during the present season. The varieties are arranged in the order of their ripening at Ithaca in 1899. (An index to the names will be found at the end of the bulletin.) As already indicated, this order of ripening is not uniform year by year. By season of ripening, we mean the date at which the first considerable numbers of fruits are fit to be eaten from the hand. Ordinarily, the varieties should be picked for market three or four days, or even a week, earlier than the dates here given. It is characteristic of most Japanese plums that even though they are uncolored when picked, they ripen up well if kept in a cool and dry place. All the pictures in this bulletin, except that on the title-page, are natural size. They are made from fruits of medium and average size. It should be remembered, however, that pictures of fruits, even though they are full size, look smaller than the fruits themselves. The histories of the varieties are recorded in previous bulletins.

1. EARLIEST OF ALL.—Fig. 24, left.

Yosebe of Bulletin 106. *Wasse-Sumomo.*

Small, round-oblong, with an indication of a pointed apex in some specimens; suture not prominent; color when fully ripe almost uniformly pink-red, with light bloom; flesh light yellow and soft, clinging to the pit, sour, with a decided almond or bitterish flavor, skin tough; first specimens picked July 10, but the larger part of the fruits ripe on July 14. The fruit drops from the stem as soon as ripe. Straw or hay should be spread under the tree to catch it. The tree is a decidedly upright grower, with small and yellowish green deeply serrate leaves, prominent stipules and reddish twigs. After having tested four or five crops of this plum, we are convinced that its chief merit is earliness and that it is too poor in quality to be recommended, particularly since the Engre is of better quality and practically of the same season.

25.—*Lutts. The largest of the very early Japanese plums.*

2. ENGRE.—Fig. 24, right.

About one-third larger than Earliest of All, not round but somewhat flattened endwise, the suture usually rather prominent; color a very little darker than Earliest of All; flesh soft and yellow, cling, sour but with almost no almond flavor, and the skin tough. Engre is practically of the same season as Earliest of All, although this year it was about one day later.

It is a distinctly better plum. We recommend it for being very early. With us it has been a prolific bearer, and the fruits are attractive. Its quality is not as good as that of Burbank and Abundance, but its great earliness commends it.

3. LUTTS.—Fig. 25.

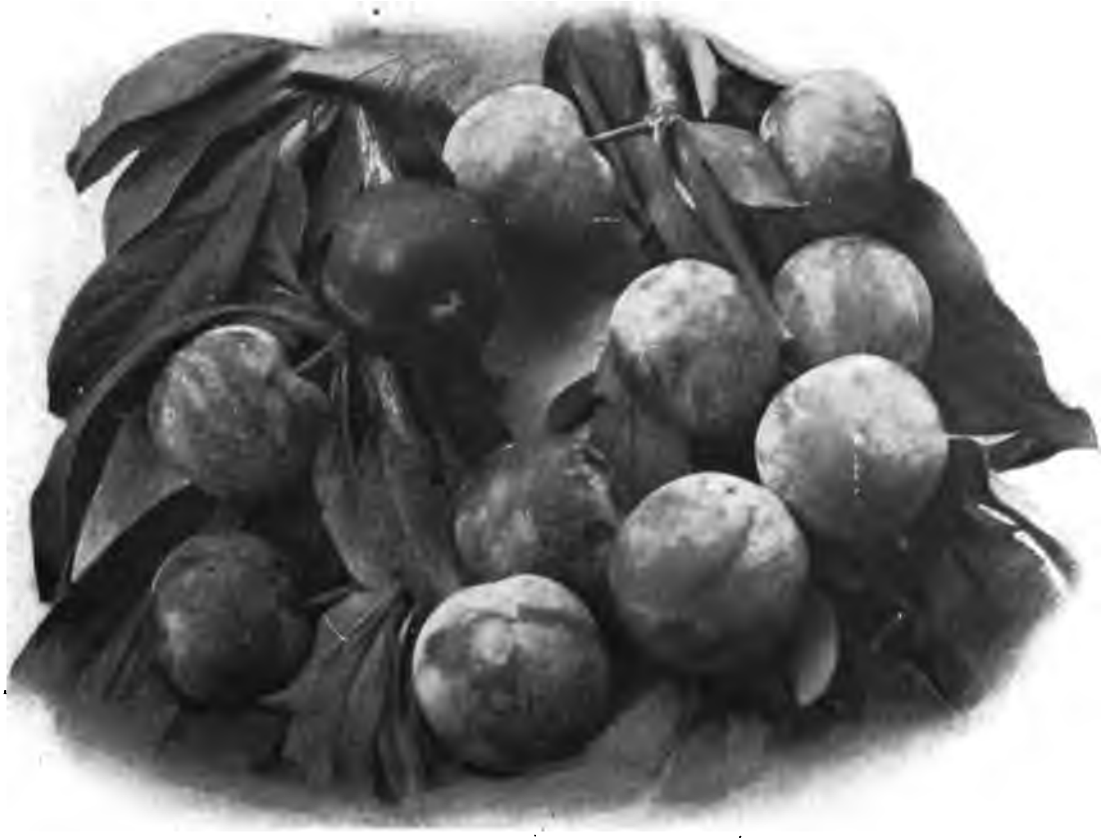
Wasse-Botankio.

Under the name Wasse-Botankio, we have fruited an excellent early plum for two seasons. It seems to have such distinct merit that we think it worthy general introduction, and I therefore take pleasure in naming it for Mr. Henry Lutts, of Youngstown, N. Y., who has been one of the pioneers in the culture of Japanese plums in this State. Fruit round-oblate with a tendency to a pointed apex, in general form and appearance very like the Burbank, but running smaller ; color dark red, marked with many very fine golden dots and covered with a heavy bloom ; flesh light yellow and soft, cling when thoroughly ripe, with only a tinge of almond flavor, but not sour nor bitter, the skin rather tough. Ripe enough for eating in the present season on the 14th of July, being four or five days later than Earliest of All and Engre. This is the largest and best very early Japanese plum which we have tested. The tree is a good grower and with us has been productive.

4. BERGER.—Fig. 26.

Strawberry. Ura-Beni. Uchi-Beni. Honsmomo, at least of some nurserymen.

Small and cherry-like, flattened endwise, with a distinct suture; color bright light red, with prominent bloom ; flesh firm and meaty, yellow, free from the very small pit and with no astringency or almond flavor, the skin not tough nor sour ; ripe this year on the 17th and 18th of July. This is one of the most distinct of all the Japanese plums. It has the flavor of some of the Domestica varieties. The handsome little fruits fall when ripe and should be caught on straw or hay spread underneath the



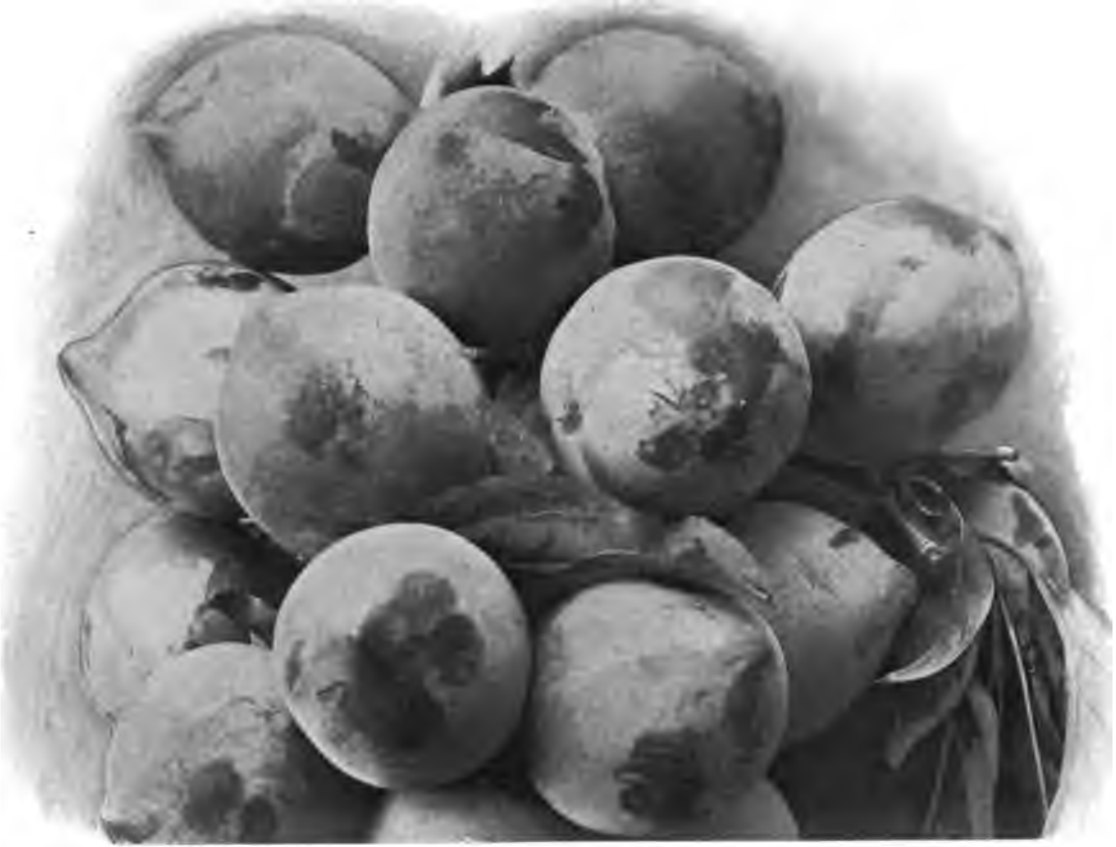
26.—*Berger. A cherry-like and attractive variety; desirable for the home garden.*

tree. The plums are not much larger than very large cherries, and, coming after the sweet cherries are gone, they seem to piece out the cherry season. The tree is a distinct and upright grower, with rather narrow and light colored leaves, and the fruits are borne well down on the older wood. We believe that the Berger is well worth growing in every home garden.

27.—*Willard. One of the early plums, but quality very poor.*

5. WILLARD.—Fig. 27.

Fruit medium to small in size, oblong, slightly angular, never pointed, the sinus slight or scarcely any, the stem cavity rather



28.—*Kerr.* *The earliest clear yellow variety.*

deep; color bright red with a heavy bloom and many minute yellow dots; flesh soft to firm, yellow, somewhat cling, with a decidedly mawkish or almond flavor, skin sour: ripened this year July 23–25. The fruit falls easily. The quality is very poor, and we believe that the variety is not worth growing, particularly since there are earlier varieties of better quality. The leaves are also very badly attacked with the shot-hole fungus, being the worst in this respect of any of the Japanese plums which we have grown. The branches have a straight, upright tendency. The leaves turn red and fall very early.

6. KERR.—Fig. 28.

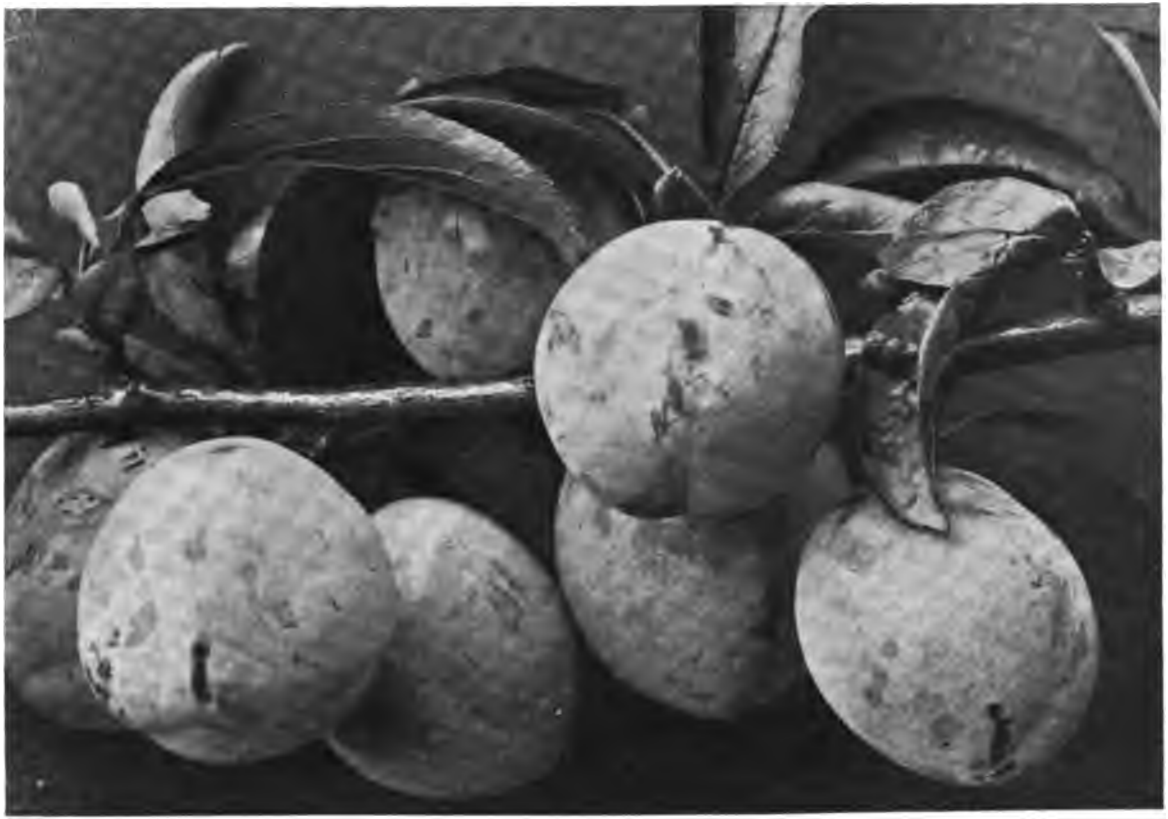
Hattonkin of some nurserymen. *Hattankio Oblong*.

Of medium size, tending to become fairly large when well thinned, tapering a very distinct long point, the suture usually well marked, stem comparatively short and stout; color orange yellow, overlaid with a thick creamy bloom; flesh firm and rather meaty and yellow, cling, sweet and of fair to good quality when well ripened; ripe this year from the 28th to 30th of July. Tree is of moderate spreading habit, much like the Georgeson; foliage strong, large and good. The Kerr is an exceedingly productive variety, and needs to be well thinned in order to produce the best results. It is one of the best of the yellow varieties. Its chief fault is that it tends to fall before it is fully colored, but the fruits ripen and color on the ground. If they are picked just before they begin to loosen from the stem and are stored or shipped, they will ripen up well.

7. RED JUNE.—Fig. 29.

Nagate no Botankyo

Medium to large in size, cordate-oblong and distinctly pointed, with a very strong suture, often lop-sided; color deep vermilion red, with a thick and handsome bloom; flesh light yellow or yellowish white, cling or partially cling, firm and moderately juicy, slightly acid to sweetish, of good quality, though not very rich, the skin slightly sour. We still believe that the Red June is one of the very best of the Japanese plums, because it is very



29.—*Red June.—A valuable second-early market plum.*

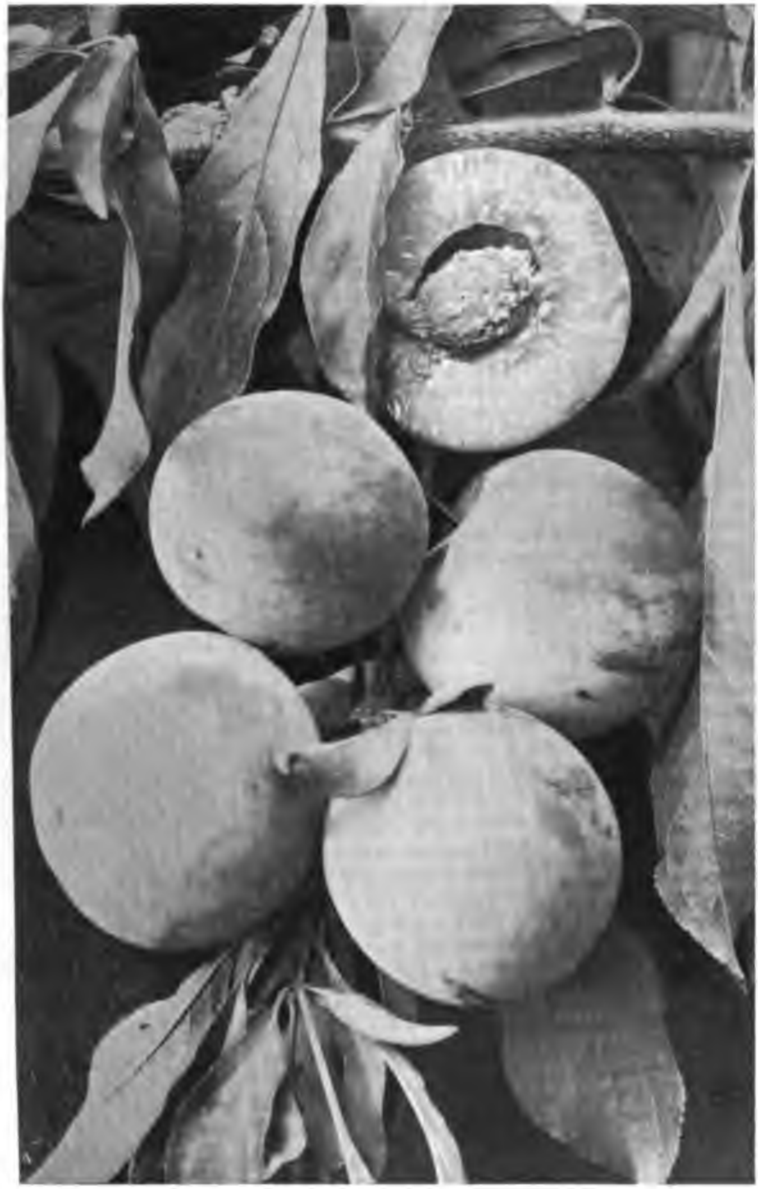
handsome and productive. It ordinarily needs heavy thinning to bring it to perfection. It varies considerably in season of ripening. This year the earliest fruits were ready for eating on July 30 and for marketing three or four days before that time. At the time that the Red June was coming into condition for eating, the Kerr was in a similar condition, Earliest of All and Lutts were all gone, Georgeson showed no sign of coloring, and the Abundance on some of the earlier trees was beginning to turn red. The Red June and Kerr are practically of the same season, although the Kerr begins to to fall from the tree a few days before the Red June is ripe. The Red June is a bushy-topped, upright grower, with yellowish green foliage and redish brown twigs. It is a well marked type. We are fruiting it on both peach and Lombard stocks.

8. OGON.—Fig. 30.

Fruits medium in size or becoming large when heavily thinned, globular or flatened endwise, not at all conical or pointed, the suture prominent; color a clear lemon yellow, with a heavy whitish bloom, rarely with the faintest indication of a blush cheek; flesh thick and very meaty, comparatively hard, free from pit, with a very peculiar musky almond flavor. Ready to eat this year August 1, although they were ready to ship, and a very few were edible, some three or four days before this time. It is practically the season of the Red June, although tending to be a trifle later. The tree is a strong, upright, grower with heavy thick foliage. It does not seem to be so uniformly productive as some other varieties, although it tends to bear very heavily at times. It is readily distinguished from other early varieties by its globular or flatened shape, by the cavity around the pit and by its peculiar flavor. Its quality is indifferent—not so good as that of the Red June nor so bad as that of the Willard. It is said to be one of the best for canning.

9. BERCKMANS.—Fig. 31.

Fruit of medium size, round-oblong with a tendency to have a blunt point, more or less angular in cross-section, the suture not prominent; color deep bright red, especially when exposed



30.—*Ogon. A second-early yellow variety.*

to the sun, more or less yellow-splashed on the shaded side; flesh firm and sweet, cling or semi-cling, becoming dry and insipid when fully ripe. Ripe this year on the 4th to 6th of August with the earliest trees of Abundance. In 1896, it also ripened with Abundance or just ahead of it. In 1897, the same trees ripened two weeks later than Abundance. It is an upright grower, with yellowish green, rather small, foliage. It is readily distinguished from all other Japanese plums which I know by the dry and mealy character of the ripe fruit.

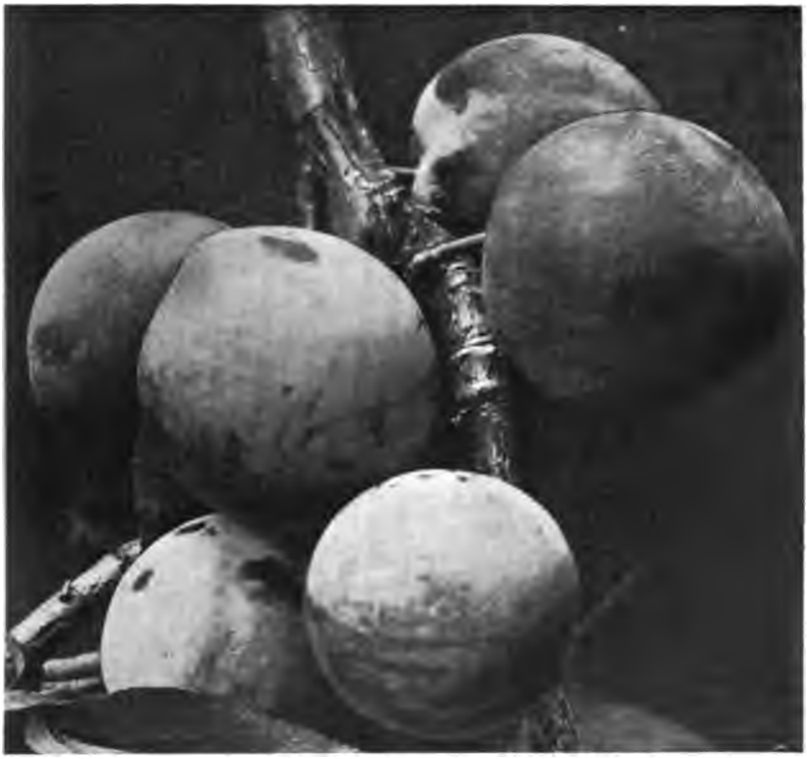
31.—*Berckmans. Distinguished, when fully ripe, by its dry flesh.*

We doubt if the Berckmans is of sufficiently high quality to recommend it for general planting, since the Abundance occupies the same season. Some of the trees which have passed for Berckmans are Abundance. The true Berckmans is distinguished by its dry flesh.

10. ABUNDANCE.—Figs. 32 and 33.

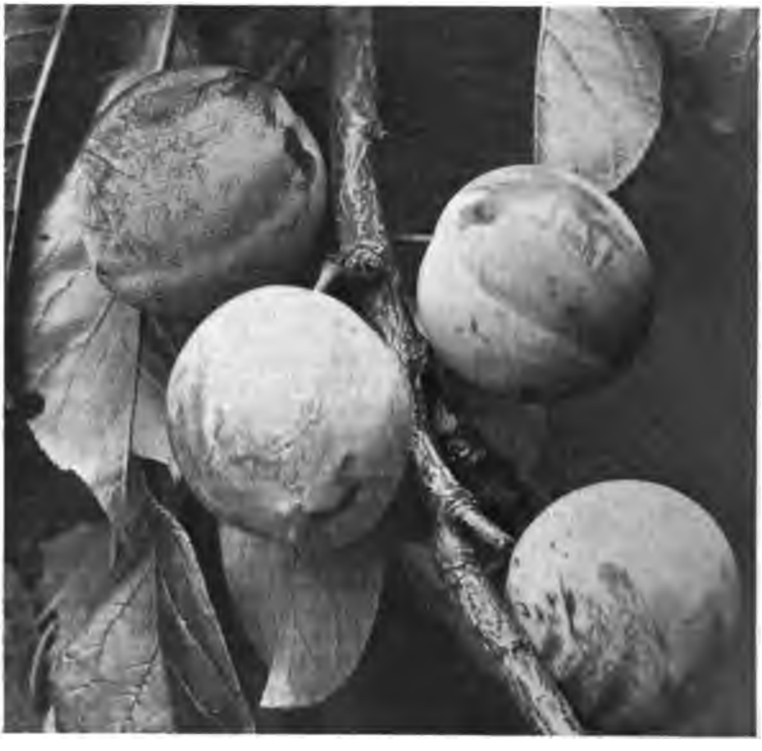
Yellow-Fleshed Botan.

Fruit medium size or varying to nearly large when vigorously thinned, round-oblong with a distinct point, the suture usually more or less prominent; color pink-coppery-red, marked with many minute dots and a thin bloom; flesh firm but juicy, sweet, with no trace of mawkish or almond flavor when well thinned or well ripened, clinging to the pit. The Abundance is a variable plum. We have stock from various sources, amongst others from some of the original trees sent out as Abundance by Lovett. The trees vary in time of ripening, the period ranging



32.—*Abundance. A good type. Perhaps the best Japanese plum.*

over a week or ten days, but they all seem to be indistinguishable. This year the first fruits were ripe on the 5th and 6th of August. The ordinary, and what I take to be typical Abundance, is shown in Fig. 32; also in Fig. 1, Bulletin 106. Some trees, however, produce an inferior grade of fruit, as shown in Fig. 33, but I cannot distinguish that this small fruit is a different variety.



33.—*Abundance. Small or inferior type.*

This small-fruited type of Abundance is the one which I distinguished in our Bulletin 62 as the Babcock. When the Abundance is well thinned, it is certainly an excellent plum and one which most people delight to eat. Its great fault is to overbear, and in that case it is very liable to the fruit-rot fungus. With us the Abundance has been less injured with this fungus than the Lombard. The light pink-red color of the Abundance will clearly distinguish the variety from all other Japanese plums which we have fruited. The tree is an upright grower, not so spreading as the Berckmans, with larger and better foliage. I believe that the Abundance is the best single variety of Japanese plum.

The Chase which we have heretofore regarded as identical with Chabot was this year perfectly indistinguishable from Abundance.

We now believe that the Douglas is Abundance; or, if different, it is very difficult to distinguish. It seems to have a somewhat drier flesh than Abundance; but Abundance varies in juiciness.

11. MARU.—See illustration on title-page.

Written also *Masu* and *Massu*.

Fruit medium in size, globular or slightly flattened endwise, usually tending to have an obtuse point, the suture slight; color dark dull red or maroon red, uniform or nearly so over the whole surface, marked with numberless minute golden yellow dots; flesh rather soft and deep yellow, with a decidedly musky almond flavor, cling or semi-cling, the skin sour; ripens with the later trees of Abundance. It is a vigorous, upright grower and productive, but the quality is poor, and the variety cannot compete with Abundance.

12. BURBANK.—Fig. 34.

Fruit medium in size, becoming large upon vigorous and well-thinned trees, round-oblong to oblong, the point not well marked, and the suture usually somewhat prominent; color orange-yellow overlaid with splashes, streaks and dots of red, giving a more or less marble appearance, but becoming more or less uniformly dense red on the cheek; flesh firm and meaty, yellow, sweet and rich, cling, the skin not sour nor unusually tough. The Burbank ripened very unevenly with us this year, some of the trees maturing their fruit only three or four days later than Abundance, whilst others were ten to eighteen days later. In 1895, as compared with Abundance on our grounds, it was a week later; in 1896, it was from one to two weeks later; in 1897, it was from two to three weeks later. The tree is an exceedingly spreading flat-topped grower and needs strong heading-in to keep it in shape. When well thinned, the fruit is large and of excellent quality, perhaps as good as any of the Japanese plums. It is also a good keeper. It usually colors up on the tree some days before it is ripe. Occasional trees ripen their fruit before the main crop of Abundance is ripe. In many cases, the fruit does not become soft and edible, even when apparently full ripe. Heretofore, we have regarded Burbank as the best all-around Japanese plum, but we are now inclined to give that place to Abundance.

34.—*Burbank. A standard mid-season variety.*

The Wassu, from Normand, was indistinguishable from Burbank in habit of tree and character of fruit in 1897 and 1898. This year a part of the fruit on our tree of Wassu ripened a week ahead of the main crop of Burbank, but some of the fruits were as late as the main crop of Burbank. We believe that it is the same thing as the Burbank.

13. GEORGESON.—Fig. 35.

White Kelsey. Yeddo Mikado.

Fruit medium or becoming medium to large when well thinned, round or round-flattened in form, usually without a point, the suture distinct; color deep bright yellow with a heavy whitish bloom; flesh firm and solid, golden yellow, of fairly good quality, cling. Ripe this year the middle of August and nearly all gone by the time the latest trees of Burbank were ready for eating. In 1897, the same trees ripened their fruit from the middle to the 20 of September. The tree is a sprawling and forking grower, intermediate

35.—*Georgeson. A yellow plum of long-keeping qualities.*

in character between the Abundance and Burbank. The fruit is a long keeper and, if picked before it is thoroughly ripe, will ordinarily shrivel before it decays. The quality is medium; it has a little of the mawkish almond flavor, and is usually not prized for eating from the hand. I doubt if it is destined to be a very popular variety. It is one of the commonest varieties.

36.—*Hunn. A small red medium-late variety.*

We refer the White Kelsey of Normand to the Georgeson from specimens which we grew this year upon grafts set on Lombard stocks. We have not fruited Mikado. One party exhibited specimens of Mikado and Yeddo at the State Fair this year, and these were the Georgeson. Mr. Normand, however, in a trade circular says that the Mikado ripens fifteen days earlier than the Yeddo. The Yeddo, as we have fruited it, seems to be Georgeson.

14. HUNN.—Fig. 36.

Burbank No. 1.

Fruit small to medium, globular, sometimes with a distinct short point, the suture more or less prominent; color something like that of Abundance but less pink, and usually a deep claret red with many minute, golden dots; flesh soft, deep yellow, cling, of fair to good quality, aromatic. Ripened this year as the Georgeson was passing out, that is, from the 20th to the 24th of August. In 1897, it ripened also at this season, but since the Red June ripened with us very late that year, we compared it in season with that variety, and therefore called it an early plum. We should now call it a mid-season to late plum. It has a slight musky flavor, but usually not sufficiently pronounced to make it disagreeable. We are more favorably impressed with it this year than we have been in the last two years. It is possible that it may deserve a place in the Japanese plums of second importance. We are fruiting it on the Lombard.

15. HALE.—Fig. 37.

Fruit medium to large, globular or somewhat globular-oblong, not pointed, the suture usually distinctly marked; color deep yellow or orange, thinly overlaid with mottled and speckled red giving the appearance of a yellow-red fruit, bearing a thin bloom and having many yellow specks; flesh soft and juicy, yellow, cling, of good quality, but the skin sour; ripened with us this year on the 24th of August. The fruit has a very slender stem and drops easily from the tree. The tree is a moderately spreading grower, being intermediate in habit between the Georgeson and Abundance. The fruit is of good quality, but for the last two seasons it has failed to color well and has dropped prematurely. The trees have not been very productive, although they have borne for three consecutive years. From its behavior thus far, we are of the opinion that the Hale should not be put in the first or leading list of Japanese plums for western New York. It follows the Georgeson, being in condition for eating when the last specimens of the Georgeson are passing.

16. WICKSON.—Fig. 38.

Fruit very large, tapering from toward the base, and long heart-shaped with a deep strong suture; color usually a deep maroon red, but sometimes tending to yellowish red; flesh very firm and meaty, dull yellow, rich but with an aromatic almond-like flavor, cling, the pit small. The tree is a very narrow

37.—*Hale. Of excellent quality; medium-late.*

upright grower with narrow yellowish green leaves. The fruit is borne far down on the old wood and not in clusters. Although it is said by Mr. Burbank that this plum was grown from Burbank seed fertilized by Kelsey pollen, I believe that it has Simonii blood. The character of the foliage and bloom, the habit of the tree and its method of fruit-bearing, together with the texture of the flesh, all point to Simonii as one of its parents.* The tree is perfectly hardy with us. It impresses us as being a shy bearer, although our trees are not yet of sufficient age to enable us to have tested this point. It certainly does not come into full bearing as early as other varieties of Japanese plums. From its habit of bearing far down on the old wood and the comparatively small amount of wood surface which it makes,

38.— *Wickson. The largest of the hardy varieties.*

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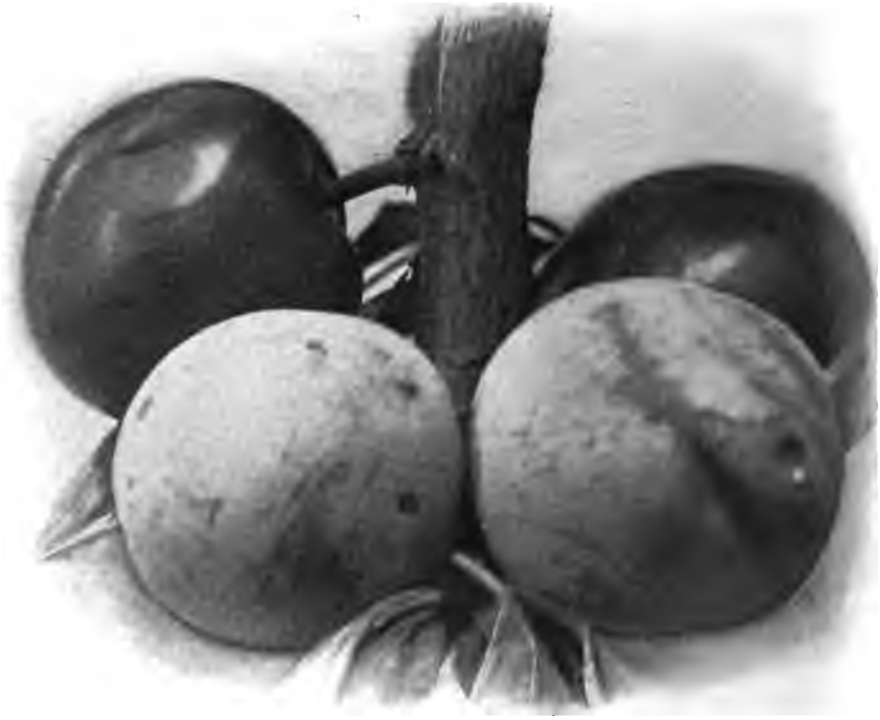
* An opinion shared by Professor Waugh. See "Hybrid Plums," Bull. 67, Vt. Exp. Sta.

it promises not to be a very prolific variety. Prunus Simonii itself has been a shy bearer with us, except one year when the trees bore exceedingly full and the branches needed to be propped. It is possible, therefore, that when the Wickson trees arrive at a greater age, they may bear full crops. Most of our Wickson fruits—of which we had few— were ripe on the 8th of September; some of them were ripe five days before that time.



39.—*Chabot. An excellent late variety.*

17. CHABOT.—Fig. 39.

Bailey. Yellow Japan. Furugiya. O-Hatankyo. Uchi Beni of some.

Fruit medium to large, oblong-conical, lacking the point, the suture usually pronounced, the the stem thick and strong ; color deep orange, heavily overlaid with light cherry red or the sunny side becoming deep dark red, with a whitish bloom and many minute golden yellow dots; flesh soft to firm, yellow, with no almond flavor, sweet, of excellent quality, cling; ripe with us this year, fit for eating, from the 7th to the 10th of September, and ready for shipping a week before that time. The Chabot is a strong, upright grower, prolific, the fruit handsome, good and long keeping. It is one of the best of the Japanese plums.

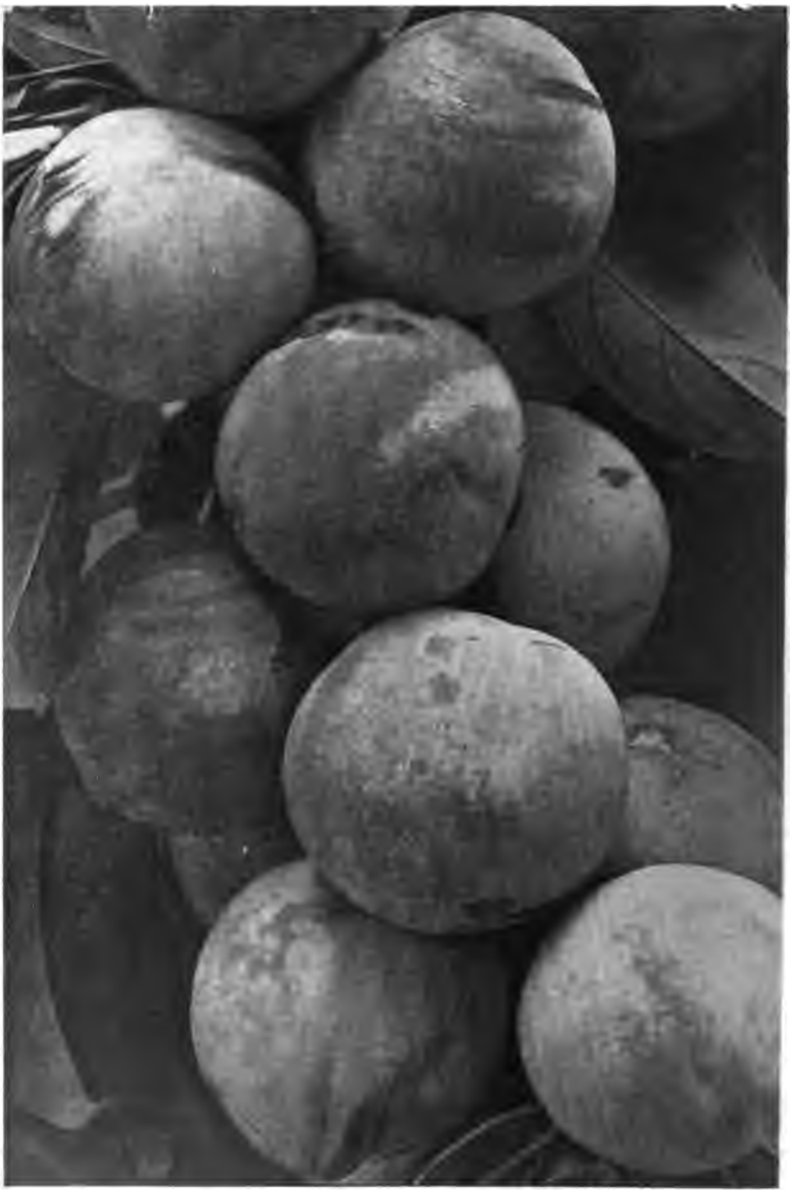
18. SATSUMA.— Fig. 40.

Blood. Yonemomo.

Fruit medium to large, round-oblong or round-conical, with a short blunt point and deep suture; color very dull dark brown-red with a heavy bloom, mottled with greenish dots; flesh hard and blood-red, very tenaciously clinging to the small pit, acerb but becoming rich and pleasant when fully ripe. This season the Satsuma was edible and also fit for market, but still hard, on the 8th and 10th of September. For the last three years the Satsuma has been a very prolific plum with us. When the trees were young they bore sparingly. Some growers complain that even when the trees are nearly mature they do not bear. It is a very long keeper. We believe that it is one of the coming Japanese plums. The red flesh may be against it in many markets. It seems to be an excellent plum for culinary purposes. The tree is a moderately spreading, but strong grower, and is distinguished from most varieties of Japanese plums by its habit of bearing spurs and short branches all along the main forks or branches of the top.

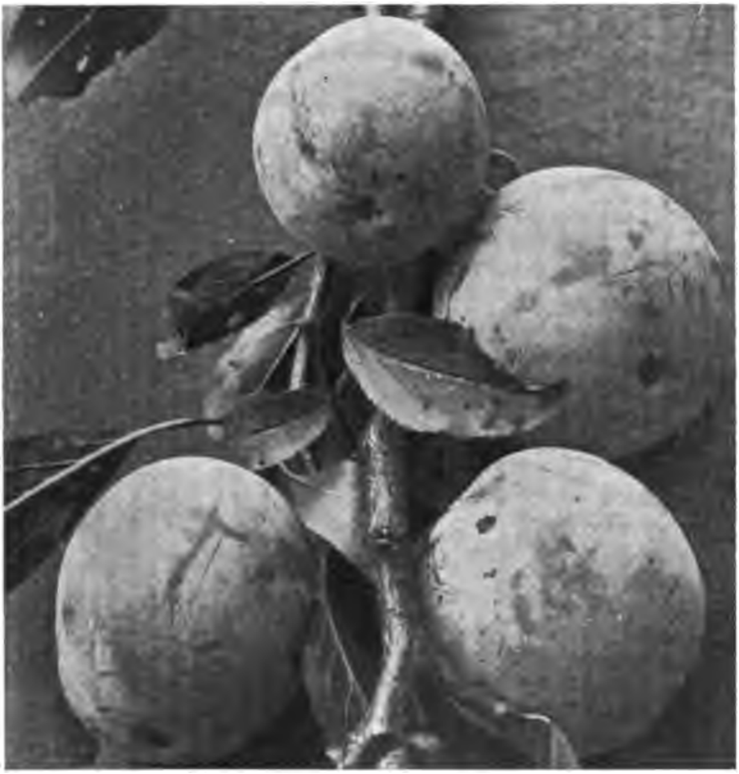
19. THE NORMAND HYBRID PLUMS.

J. L. Normand, Marksville, La., has distributed a number of so-called Japanese plums under numbers ranging fom one to twenty. They are hybrids of apparently unrecorded parentage. Mr. Normand advertizes (1899): "Out of over 30,000 seedling Japan plums we have fruited the past three years, we have selected 20 varieties. * * * Most of these



40. —*Satsuma. The latest of the Japanese plums in New York.*

plums are a cross between the Japan and our native plums." One of these (No 15) we named Louisiana in our Bulletin 139, giving a picture thereof. In naming this plum, we did not recommend it; but since these numbered plums are offered to the trade, it seems to be necessary to name them. This year we have fruited two others of these numbered plums, and, with Mr. Normand's consent, we have given them names.



41.—*Georgia (Normand No. 20). An evident hybrid.*

Georgia (Normand No. 20). Fig. 41. Fruit of medium size but variable, oblong, very blunt or sometimes with a cavity at the apex; color green or light greenish yellow when first ripe but becoming pinkish, with a very thin nearly white bloom; flesh soft, watery, sweet, cling, with a peculiar breaking skin ; ripe Aug. 24, some days in advance of the Louisiana. The tree has the habit and fruit of the Louisiana, but that plum is more distinctly heart-shaped. In common with others of these hybrids, Georgia drops when it is still green in color, although it is edible at that time, and a pinkish color appears if it is allowed to lie on the ground. The tree is a spreading, twiggy grower, with slender, glossy, half-zigzag branchlets and foliage suggestive of some of the native plums.

Alabama (Normand No. 5).— Fruit of medium size, round-conical or heart-shaped ; color light bright yellow when ripe, with perhaps a faint pinkish cheek, covered with a very thin bloom; flesh soft, sweet and juicy, cling; ripe the 14th of September. The latest of the plums reported in this bulletin. The fruits drop before fully ripe, but develop an excellent quality after they have fallen. On account of its lateness, it is possible that this plum may have commercial value. The habit of the tree is like that of the Georgia.

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L. H. BAILEY.

ABRIDGED EDITION.

Bulletin 176. **December, 1899.**

Cornell University Agricultural Experiment Station,

ITHACA, N. Y.

ENTOMOLOGICAL DIVISION.

THE
PEACH-TREE BORER.

"June 15, 1749. Peach trees have often been planted here (Albany, N. Y.), and never would succeed well. This was attributed to a worm which lives in the ground, and eats through the root, so that the tree dies."—*Peter Kalm, in his Travels into North America, Translation by Forster, vol. II., p. 244.*

By M. V. SLINGERLAND.

PUBLISHED BY THE UNIVERSITY.
ITHACA, N. Y.
1899.

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* Absent on leave.

THE PEACH-TREE BORER.*

Sanninoidea exitiosa Say.

Order LEPIDOPTERA; family SESIIDAE.

ALMOST every commercial peach-grower realizes that his success oftentimes largely depends upon his ability to prevent the weakening or destruction of the trees by that king of all peach insect pests—the peach-tree borer.

We suppose that but comparatively few of the peach-trees, which have been planted east of the Mississippi River during the last quarter of a century, have lived to produce a crop of fruit without suffering more or less from this dreaded borer.

Several years ago Professor Comstock planned an extensive series of experiments with many of the so-called "remedies" for this pest. A peach orchard of nearly 400 trees was set near the insectary in 1893 for the sole purpose of experimenting against the insect. Portions of this orchard are shown in figures 52 and 53. These experiments have cost much in time and labor, but no effort has been spared to render the results reliable and as conclusive as possible.

ITS HISTORY AND DISTRIBUTION.

It is an American insect, and now occurs only in the United States and Canada. It has been a serious menace to peach-growing for more than a hundred years. It has to be fought in nearly every state east of the Rocky Mountains, but does not occur in the Pacific coast states.

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*This bulletin is a brief statement of the conclusions deduced from the detailed evidence submitted in Bulletin No. 176 of this Station, on The Peach-tree Borer. Only a small edition of the complete Bulletin of 80 pages is published. On application a copy of the complete Bulletin will be sent to any one specially interested in the details of the insect's life or in our experiments in combating it.

ITS NAME.

The insect is usually designated by the popular name of "peach-tree borer." It received its scientific name of *exitiosa*, meaning "destructive," in 1823.

ITS CHARACTERISTICS.

Most peach-growers have seen this insect in its destructive or "borer" stage, and doubtless but few have ever seen it in any other form. However, the peach-tree borer, like all the butterflies, the moths, the beetles, the flies and some other insects, passes through four different stages (see figure 57 on last page) during its life. It begins life as an *egg*, from which hatches the *larva* or "*borer*," which has to pass through a *pupa* stage, from which the *adult* or *moth* form of the insect emerges.

When fully grown the "borer" is a light yellow, worm-like creature whose general characteristics are well shown in figure 42. It measures about an inch in length.

The adult form or the parent of the peach-tree borer is a moth. A glance at figure 43 will show how easily one might mistake the moth, especially a male, for a wasp, so striking is the resemblance; the unlikenes of the two sexes is well shown in the figure. The moths are of a deep steel-blue color, with narrow yellow stripes on the male and a broad orange band on the female.

FOOD-PLANTS.

The peach-tree borer is *par excellence* a peach pest, but may also attack both the wild and cultivated varities of the cherry, the cultivated varities of the plums or prunes, nectarines, apricots, flowering almond shrubs, and azaleas. The indications are that its original food-plants may have been both the wild plum and the wild cherry.

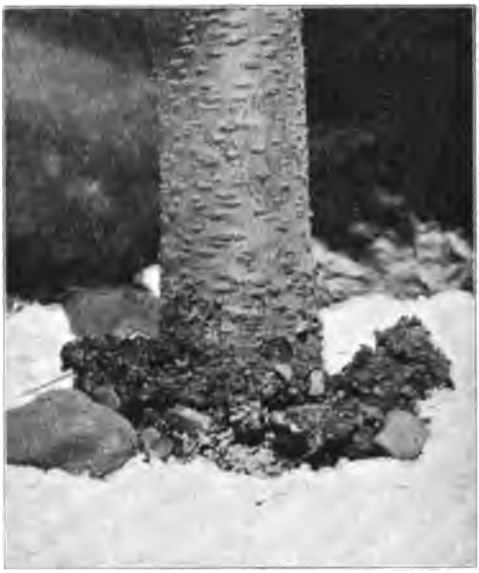
HOW IT SPREADS.

It can be easily transported for long distances on infested trees, and this is doubtless the way in which it usually reaches new localities. It is doubtful if there is a peach nursery to-day east of the Rocky mountains that is not more or less infested with the peach-tree borer. It is one of the most serious of the insect pests that are now being sent out by nurserymen.

APPEARANCE OF INFESTED TREES.

One can usually quickly determine if a peach-tree is infested with borers. The work of the borer always causes the tree to exude a large amount of a mucilaginous matter which forms a gummy mass around the infested portion, as shown in figure 45.

Where the peach-tree borer attacks plum or prune trees, however, there is but a slight, if any exudation of this gummy substance, hence one cannot so readily detect its presence on these trees. It is thus more difficult to find the borers in plum or prune trees, and this makes it harder to combat them in these trees.

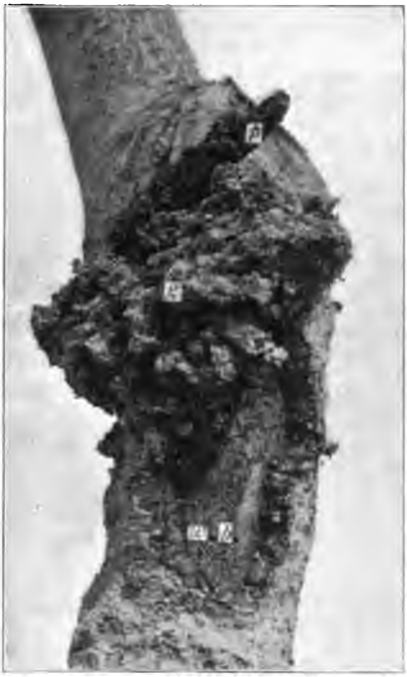


45.—*Base of an infested peach-tree, showing the gummy mass surrounding the tree.*

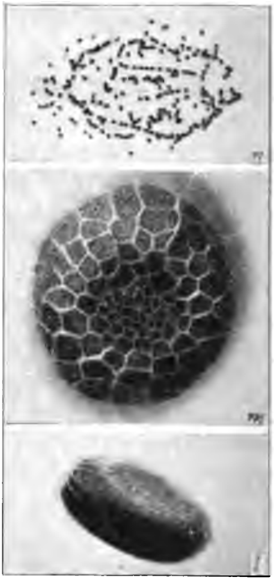
THE STORY OF THE PEACH-TREE BORER'S LIFE.

But few peach-growers stop to marvel over the wonderful transformations exhibited by this insect in passing through the four stages—the egg, the "borer" or larva, the pupa and the adult moth—of its life-cycle. And yet, our more successful fruit-growers are fast realizing that they must know more, and, in fact, cannot know too much, about the lives and habits of their insect foes in order to fight them the most successfully.

In New York the moths (figure 43) begin to appear in the latter part of June and continue to emerge until September. A few hours after emerging the females lay their small, oval, brown eggs (figure 50) on the bark of the trunks of the trees from six to eighteen inches from the ground. From these eggs there hatches, in a week or ten days, a minute larva—the young borer—which at once works its way into a crevice of the bark, and soon begins feeding on the inner layers of the bark. It continues to feed in this manner, gradually enlarging its burrow under the bark, until winter sets in, when it stops feeding and hibernates during the winter, either in its burrow or in a thin hibernaculum made over itself on the bark near the surface of the soil. The winter is always spent as a larva or borer, a few of them being nearly full-grown, but most of them being considerably less than one-half grown. In the spring, usually about May 1st in New York, they break their winter's fast and grow rapidly for a month or more, most



46.— *Work of a single borer in a peach-tree, natural size;* w b, *burrow of borer;* g, *gummy mass;* p, *pupa projecting from cocoon.*



50.—*Eggs of peach-tree borer, natural size at* n; *one egg, enlarged at* l; *micropyle end of egg, greatly enlarged at* m.

of them getting their full growth in June. See figure 46. They then leave their burrows and spin about themselves a brown cocoon (figure 48) at the base of the tree, usually at the surface of the soil. A few days after its cocoon is made, the borer changes to a pupa (figure 49) in which stage it remains for about three weeks, usually in June in New York. From the pupa the moth emerges, thus completing its life-cycle in a year, fully ten months of which are usually spent as a borer in the tree, the remainder or a little more than a month being spent in the egg, pupa and adult stages. About the middle of July all stages of the insect may be found in some orchards. The above brief sketch of the life of the peach-tree borer will apply in general to most localities in the United States north of Washington, D. C. In Canada the moths do not begin to fly until about a month later, while in the South they appear a month or more earlier, so that the dates in the above sketch will not apply to these regions.

ITS NATURAL ENEMIES.

As the peach-tree borer spends most of its life under the bark beneath the surface of the soil, it is not readily accessible to enemies. But it does not entirely escape, for several insects have discovered a way to include this serious peach pest in every course served to their growing progeny. At least eight different enemies of the peach-tree borer have been found, and all of them are parasitic Hymenoptera.

There are indications that in some localities the enemies of the peach-tree borer may play quite an important part in checking the normal increase ot the pest.

Some General Conclusions Regarding Methods of Fighting the Peach-Tree Borer.

Although American peach-growers have been fighting the peach-tree borer for a hundred and fifty years, the results from to-day's methods of warfare are not strikingly different from those recorded by Peters in 1806. Most of the applications now recommended were devised nearly a century ago.

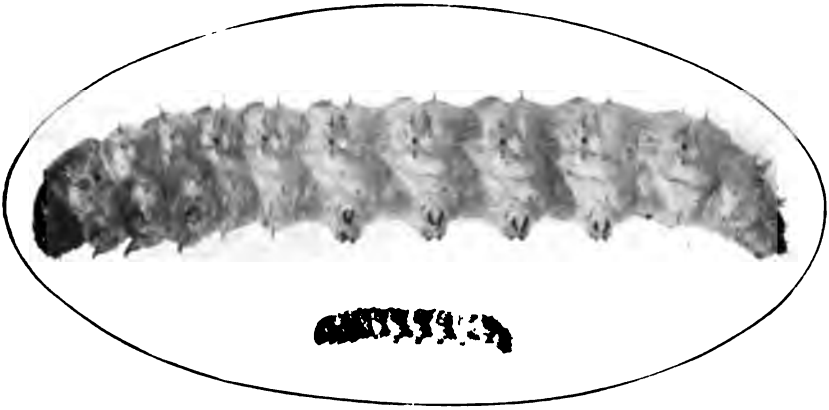
Cultural methods.—Different cultural methods such as budding on various stocks, irrigation, and cultivation seem to have little or no effect upon the number of the borers. But to make a success of peach-growing it is usually necessary to thoroughly cultivate and feed the trees, and we believe the borers can be controlled more successfully and much easier in such an orchard.

Our experiments.—During the past five years we have conducted the most extensive and scientific series of experiments ever attempted. An experimental orchard of 400 peach-trees was set for the sole purpose of testing the so-called "remedies." Portions of this orchard are shown in figures 52 and 53. The details of the plan and extent of these experiments are discussed in the unabridged edition of this Bulletin. We thoroughly tested about 25 representative methods for combating the peach-tree borer.

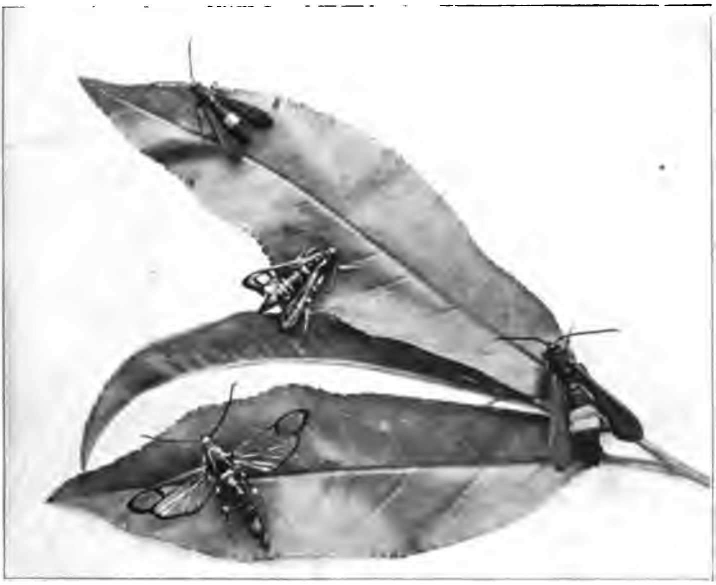
Vulnerable stage of the insect.—The insect is open to successful attack only in its larva or borer stage and in ts pupa stage; the pupæ are reached only by searching for the cocoons and destroying them.

DESTRUCTIVE MEASURES.

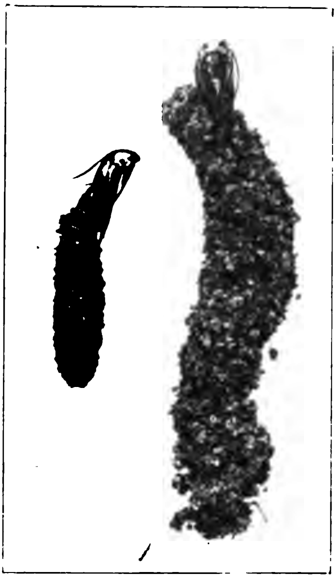
Of the destructive or killing methods recommended, the "*freezing*" *method* and the use of *carbon bisulphide* are unsuccessful and unsafe. *Boiling water* and similar methods have been successfully employed, but they are impracticable on a large scale and may injure or kill the trees.



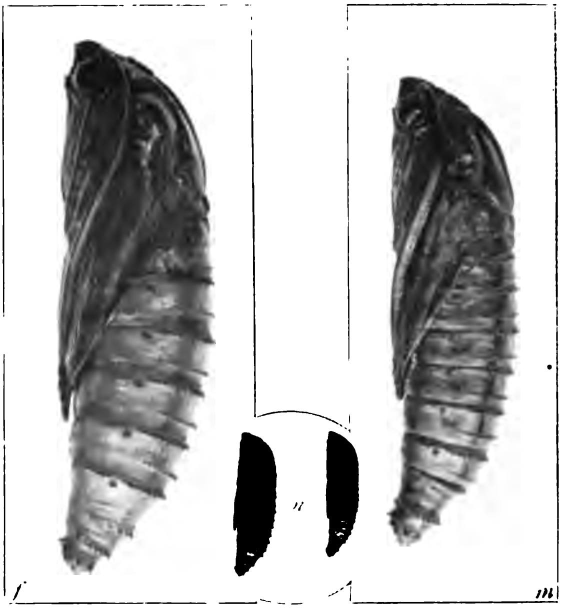
42.—*The larva of the peach-tree borer, natural size and enlarged.*



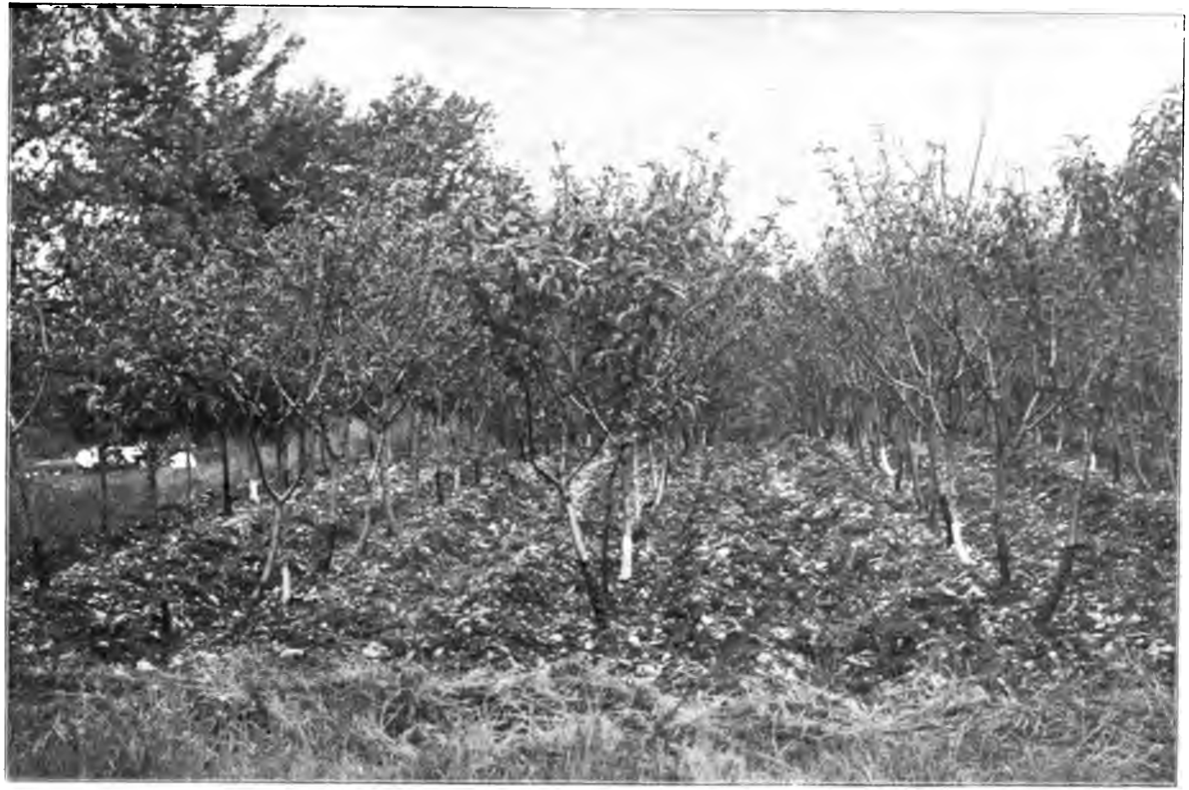
43.—*Moths of the peach-tree borer, natural size. The upper one and the one at the right are females.*



48.—*Cocoons of the peach-tree borer, natural size.*



49.—*Pupæ of the peach-tree borer; natural size at* n; m, *male pupa, enlarged;* f, *female pupa, enlarged.*



52.—*View in the experimental orchard in May, 1897, looking east down the rows. Note the different applications on the bases of the trees.*

53.—*View in the experimental orchard in May, 1897, looking south.*

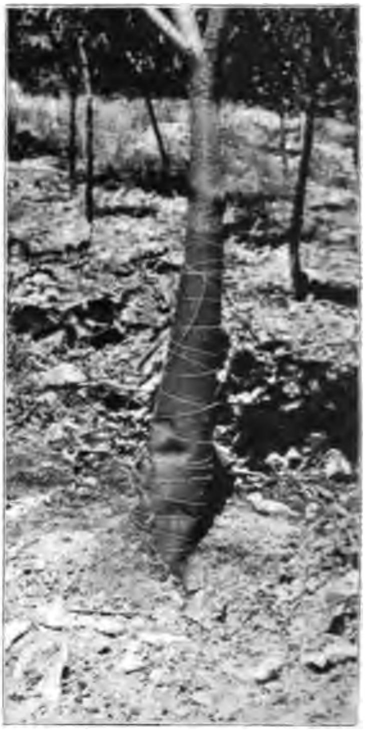
The "digging out" method.—The "digging out" method the only thoroughly successful and safe way of killing the peach-tree borer. This method is expensive in time and labor, but our experience leads us to believe that any other equally as successful method will cost just as much. To make it a success, the "digging out "should be thoroughly done, not only on every tree in the orchard, but also on all "old relics" of peach-trees in the immediate neighborhood. A half-dozen such "old relics" left untreated near by served to thoroughly re-stock our orchard with borers every year, so that our "digging out" method, although practiced thoroughly each year, never reduced the numbers of the borers below the danger limit. This is a very important factor in the success of the "digging out" method. Under certain millennial conditions, we believe the numbers of borers could be reduced to the minimum in an orchard by this method alone. Practically every peach-grower, who makes any pretensions of fighting the borers, digs them out at least once a year. Many then apply some wash or other device, but curiously enough, they usually attribute any success they may seem to have, not to the "digging out" process, where most of the credit usually belongs, but to the other preventive applications. As our experiments show, however, the application of certain preventive measures after the borers have been dug out, is not a waste of energy where several "old relics" are left untreated near by, or if a neighbor's peach orchard a few rods away is neglected. As these conditions usually prevail in the neighborhood of most peach orchards, we doubt if the "digging out" or any other method used alone, with a few possible exceptions, can be depended upon to reduce the number of borers to the minimum. But we believe there are several combinations of this destructive method with a preventive application which will give better results than either one alone in most orchards, and will keep the pest under control. Dig out the borers in June or in June and September in northern peach-growing districts.

PREVENTIVE MEASURES.

Plants.—There is little evidence to show that the odor of any plant, like red cedar or tansy, will have any influence on the numbers of the borers when such a plant is set with the tree; such plants would not be desirable adjuncts to peach-growing for other reasons.

Tobacco.—It has been recommended to pile or scatter various substances around the base of the tree to keep out the borers but only two of these deserve serious consideration.

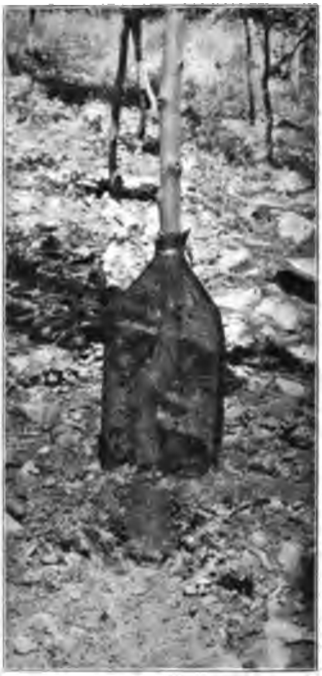
Nearly a century ago good results were reported from the use of tobacco wound around the base of peach-trees. We tested tobacco stems (midribs of the leaves) from a cigar factory, and the results astonished us. Evidently the tobacco kept out from two-thirds to five-sixths of the borers. We are not sure how the stems acted on the insect, but our results indicate that, where tobacco stems are cheaply obtainable, they will prove a good preventive from the attacks of the peach-tree borer.


54. — *Peach-tree treated with tarred paper in the experimental orchard.*

Mounding.—By this old and much-discussed method we apparently kept out from one-half to seven-tenths of the borers. We do not understand just how the mounds of soil keep out the borers, and we doubt if it would give as good results if not practiced in connection with the "digging out" method. The mounding method evidently has considerable value as a preventive and is perhaps the cheapest method yet devised. It is the most practicable method yet suggested for combating the insects in nurseries.

Paper protectors.—In the early days, *cloth* and similar protectors were used, but all were soon superceded by the less expensive and equally as effective *paper bandages*. We kept out from one-half to seven-eighths of the borers with the tarred paper protector shown in figure 54. And doubtless where rains and winds are not too prevalent to interfere with an ordinary *newspaper protector*, it would give equally as good results as the tarred paper; some report injury to the trees by the use of tarred paper, but our trees suffered no injury from its use. Paper protectors, when carefully put on and kept intact during the danger period, will prove a valuable and very cheap preventive measure, especially when combined with the "digging out" method.

Wire-cages.—Wooden boxes or tiles placed around the trees are too expensive and the evidence shows that they afford little protection. The device shown in figure 55, however, is strongly recommended by most recent writers, and, theoretically, it is an ideal protection from the ravages of this pest. We confidently believed that we had solved the problem of how to keep out the borer when we placed these wire mosquito-netting cages around some of our trees. But it was a case of misplaced confidence, for our theory was completely demolished when we examined the caged trees the next year. The cages apparently proved an attraction to the insect, for nearly twice as many borers got into the caged trees as into those untreated.



55. — *Wire-cage protector in position on a peach-tree in the experimental orchard. Theoretically a perfect protector, but practically a useless device.*

Washes.—The favorite method of preventing the ravages of the peach-tree borer has been, for at least a century, by the use of a *wash* of some kind. More than 50 different washes have been concocted, most of which are valueless as preventives, and some of which will injure or kill the trees. We tested 18 washes.

An asafœtida and aloes wash was not offensive enough.

Tallow should have given good results theoretically, but it proved wholly useless ; this was a great surprise to us.

Ordinary soap or whale oil soap, even two applications, offered little or no protection. The addition of *Paris green* to a soap wash will not increase its effectiveness, and it may injure the trees. *Carbolic acid soaps* or the *Shaker wash* would afford no more protection than ordinary soaps, we think.

Whitewash or whitewash and linseed oil washes were wholly ineffectual in our experiments. We doubt if *whitewash* and *glue*, or *Bordeaux mixture* have better preventive qualities.

By making two applications the same season of *Hale's celebrated wash* we succeeded in keeping out from one-third to one-half of the borers. This wash will not remain intact long enough in New York State, hence it is of little value unless applied twice, which makes it too expensive a process. We cannot see how *Stedman's* or other variations of Hale's wash could afford any greater protection from the borers.

Two applications the same season of a *lime*, *salt* and *sulphur wash* and a *resin wash* gave little encouraging results to peach-growers.

A Paris green and glue wash killed our trees in a few weeks.

White paint proves to be quite an effective wash, keeping out from one-half to five-sixths of the borers, but it may injure young trees, and we doubt its proving as effectual on old trees.

White paint and Paris green or green paint is quite an effectual wash but it seriously injured our young trees, and is therefore not to be generally recommended.

The Hydraulic cement wash which has recently attracted considerable attention, makes an ideal coating over the bark, but we did not succeed in keeping out any borers with it, thus shattering another theoretical ideal.

Printer's ink, although it apparently kept out nearly one-half of the borers, it injured our trees, and thus cannot be recommended.

Raupenleim and dendrolene kept out all of the borers, but killed all the trees.

Pine tar kept but a few borers out of our trees.

Gas tar proved to be the best application we tested. We used it freely on the same trees for three successive years without the slightest injury to the trees and it kept out nearly all the borers. We had been led to believe that tar was very injurious to young trees, and confidently expected to see our trees die each year after being treated with it. But the trees kept just as healthy and grew as thriftily as any others in the orchard. Let the trees become thoroughly established and get a year's growth, and it is our experience that tar can be used with safety on them. Go slow with it, by first testing it on a few trees in your orchard. We believe it will prove equally effective whether the borers are dug out or not, and from no other application yet devised would we expect to get such results when used independent of the "digging out" method.

There are a few miscellaneous washes of very doubtful value.

Some general conclusions regarding washes.—*Lime* and some kind of *soap* are often the principal ingredients of washes. Our experience leads us to believe that neither of these substances exercise any preventive effect on the peach-tree borer. Furthermore, climatic conditions in New York and doubtless in most northern peach districts, will cause any wash containing much lime to scale off and thus render it ineffective before the moths have stopped laying eggs. Thus *soap* and *lime* or *clay* are useless ingredients and lime may seriously interfere with the effectiveness of a wash in moist climates.

We do not believe a poison like *Paris green* adds anything to the effectiveness of a wash, and it may prove a dangerous ingredient, as with glue or white paint. The theory upon which the poison is supposed to work is a wrong one. The newly-hatched borer does not deliberately eat its way through the wash and thus get some of the poison, according to the theory, but it seeks a minute crack or crevice and works its way in below the surface bark, on which the wash is applied, before it begins to eat. We believe this last fact, regarding the entrance of the newly-hatched borer into the tree, will explain much of the ineffectiveness of washes. It is very difficult to so thoroughly cover the bark of even a young peach-tree that many minute cracks will not be left or soon be made through the wash by climatic conditions or by the growth of the tree.

Crude carbolic acid is another favorite ingredient in washes. Hale says it is the "meat" of his wash, on the theory that its odor is offensive to the moths. In our experience in combating the peach-tree borer or any other insect, we have seen little or no evidence that substances having offensive odors had any repellant effect in keeping the insect away from the food-plant of its progeny. *Asafoetida* did not in our experiments, and we do not believe that any of the effectiveness of *tarred paper* protectors was due to their odor, for others get just as good results from newspapers; they form a mechanical and not an odorous barrier to the insect. Hence, we do not believe that *carbolic acid* is a useful ingredient of washes.

Most, perhaps all, of the washes act simply as a preventive, mechanical coating over the bark to keep the newly-hatched borers out. Such substances as *raupenleim*, *dendrolene*, and *gas tar* seem to be ideal washes but the first two usually kill young trees, and the last also has a similar reputation in some localities, although we saw no evidence to indicate that tar was injurious to well-established young peach-trees. Perhaps some one can so modify these ideal washes as to retain their effectiveness as a preventive and yet eliminate their plant-injuring qualities. Future compounders of washes should work along this line.

We think that most of the above generalizations regarding washes may also apply to washes designed to prevent the work of the apple-tree borer.

When to apply washes or other preventive measures.—In New York the applications should be made between June 15th and July 1st, and they should remain in perfect working order until October 1st. In Canada, July 15th will usually be soon enough to make applications, and they should last until November.

In the South, the applications should be made in April and they will apparently have to last for three or more months.

Final conclusions.—In our four years of warfare against the peach-tree borer we have been thoroughly convinced that it is a very difficult insect enemy to control. No method of fighting it has yet been devised by which the peach-grower can hope to get a single year's respite ; the trees must be treated anew each year and thus the warfare is a perpetual one.

The following substances injured or killed our trees and are therefore classed as *dangerous :*

Paris green and glue.
Raupenleim.
Dendrolene.
White paint.
White paint and Paris green.
Printer's ink.

The following is a list of the things we found to be practically *ineffectual* or *useless :*

Wire-cages.
Carbon bisulphide.
Asafoetida and aloes.
Lime, salt and sulphur.
Resin wash.
Hard soap.
Tallow.
Tansy.
Whale-oil soap.
Whitewash.
Lime and linseed oil.
Hydraulic cement wash.
Pine tar.
Hale's wash (1 application).

The following methods proved to be *quite effective*, that is most of them kept out over ½ of the borers.

Hale's wash (2 applications) kept out ⅓ to ½,
Mounding kept out ½ to $\frac{7}{10}$.
Tarred paper kept out ½ to ⅞.
Tobacco stems kept out ⅔ to ⅝.

We would expect equally as good results from the "*digging out*" *method* applied under the conditions stated on page 9.

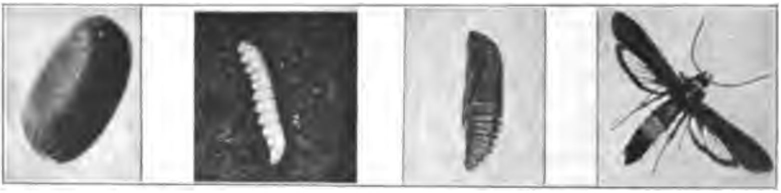
Gas tar gave us the best results of anything we tried.

We doubt if the applications listed as *quite effective* would prove as effective if used alone, hence we would recommend that they be combined with the "digging out" method, for the reasons mentioned on page 9. Make whichever combination best suits your conditions.

If you find, after a preliminary test on a few trees that you can use *gas tar* without injuring your trees, we believe it will prove to be the most effective and cheapest method of fighting the peach-tree borer; but use it carefully and intelligently, as trees have been injured by its use.

We began this investigation confident that some sure preventive of the entrance of the borers into the trees would be found. There was nothing lacking on our part to have the substances we tested do all that they were recommended or expected to do. We did not accomplish our ideal, but we have demonstrated that nine-tenths of the methods recommended are useless. Our experiments furnish much definite data for future workers, and form a definite basis on which to make suggestions regarding methods of fighting the apple-tree borer and other borers. Our experiments must lead to a much more rational and intelligent warfare against the peach-tree borer. Peach-growers will now *know what not to do*, which is often equally as valuable and important as to know *what to do*. Finally, our experiments have enabled us to point out with confidence certain methods by which the peach-grower may hope to control his worst insect enemy—the peach-tree borer.

MARK VERNON SLINGERLAND.



57.—*The four stages—egg, larva or "borer," pupa, and adult or moth—of the peach-tree borer's life; all natural size except the egg, which is much enlarged.*

Bull[redacted]January, 1900.

Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

HORTICULTURAL DEPARTMENT.

SPRAYING NOTES.

By L. H. BAILEY and Others.

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ITHACA, N. Y.
1900.

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CORNELL UNIVERSITY, ITHACA, N. Y., Jan 1, 1900.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir :—The following account is a summary of the experiments of 1899 on the spraying of plants. These experiments were made under the direction of Professor Bailey. The work was begun by H. P. Gould, but after his withdrawal to the Maryland Agricultural College it was continued by S. W. Fletcher. The chemical work was done by G. W. Cavanaugh, assistant chemist to the Experiment Station. Other materials than those reported have been tried, but it seems unwise to make any discussion of them, since the results were not satisfactory.

Respectfully submitted,

I. P. ROBERTS,
Director.

FORMULAS.

Bordeaux Mixture.

Copper sulfate (blue vitriol)	6 pounds.
Stone or quick lime	4 "
Water	1 bbl. (45 to 50 gals.)

Dissolve the copper sulfate in 2 gallons of hot water; or put it in a coarse sack, as burlap, and hang this in 4 to 10 gallons of cold water. Use only an earthen or wooden vessel. Pour the copper solution into the spraying barrel and fill the barrel half full of water. Slack the lime, dilute it to 10 to 15 gallons, *never less*, and pour this milk of lime into the spraying barrel through a wire strainer of about 30 to 40 meshes per inch. Add water to fill the barrel and stir the mixture vigorously. Bordeaux should be well stirred every 4 to 5 minutes when spraying. Few agitators are satisfactory; a wooden paddle worked by hand power is good.

Bordeaux mixture ifself should always be made fresh for each application, but stock solutions of copper sulfate and lime may be kept to advantage when the spraying operations are extensive. Copper sulfate may be dissolved in water at the rate of 1 pound per gallon; and quick lime slacked at the rate of 1 pound per gallon. For a barrel of Bordeaux, take 6 gallons of vitriol solution and 4 gallons of milk of lime. It is better, however, to use the ferro-cyanide test when the lime is taken from a stock solution. Both stock solutions should be kept covered to prevent evaporation.

Arsenite of Lime.

White arsenic	1 pound
Stone lime	2 "
Water	1 gallon

Boil together for forty-five minutes. This stock solution may be kept indefinitely in a closed vessel. Some green dye stuff may be mixed with it to prevent mistaking it for other material. One quart of the above per barrel will be sufficient for most insects.

The "Kedzie Mixture" is made by boiling together 2 lbs. of white arsenic and 8 lbs. of sal soda, in 2 gallons of water, until the arsenic dissolves. One pint of this stock solution and 2 lbs. of slacked lime are sufficient for 40 gallons of the spraying mixture.

Paris Green.

For most purposes 1 pound is used in 150 gallons of water. In some cases a more dilute mixture is made; and on potatoes some persons use a stronger one (1 pound to 100 gallons). The poison distributes better in the water if it is previously dampened and worked into a paste. To every 100 gallons of the mixture add 1 or 2 pounds of lime.

GENERAL ADVICE.

L. H. BAILEY.

Each succeeding year emphasizes the importance of spraying. There is no longer any doubt that the operation is based on rational principles and is demanded by the increasing incursions of insects and fungi. Yet a man says, "I sprayed this year, and it did no good. Shall I spray next year?" A man may insure his barn this year and it does no good; but he insures it again next year. My neighbor put in a tile drain last spring, but it did no good this year: I do not believe that he will dig it up. My neighbor believes in tilling to save moisture; yet two years ago he had too much moisture, but I notice that he did not abandon tillage last year. The wise man takes precautions.

Farming, like any other business, should be ruled by ideals. The good farmer sets a mark and tries to attain to it. He knows that the mark is right and the effort is right, even though incidental results now and then seem to contradict. The experiences of a single season do not prove nor disprove things which are true. We know that sprays kill insects and check the spread of fungi: and we know that the insects and fungi are with us. Lay out a course of action to accomplish a desired result: modify your practice as the case requires, but stick to the action.

* * *

What is new in spraying? Perhaps nothing which experimenters are ready to recommend; but we know some things better than we did last year. One of these things is the fact that the old kerosene and soap emulsion—the vilest of concoctions—seems to be doomed. The kerosene and water emulsion is to take its place. The insecticidal properties of this mixture have long been known, but it has needed a practicable mechanical device to mix them. There are two great difficulties in this mechanical problem—the difficulty of making a mathematically correct mixture of the water and oil, and the difficulty of securing power enough to mix the liquids and to throw the spray the required distance. It is scarcely to be expected that the automatic kerosene-and-water mixing pump can ever throw a spray so far as one which expends all its energies in throwing the spray. These automatic pumps are not yet perfect, but some of them are perfect enough to be useful and reliable; and they indicate that we may expect better things. I do not say that the kerosene-and-soap emulsion is already out of date—only that the indications are that it will become less and less important.

* * *

Shall white arsenic be used as a substitute for Paris green? This is not a new question. Experiments on this point were made by Kilgore as early as 1890. The arsenic is combined with lime to form arsenite of lime. There is no question as to the efficacy of the mixture, or its safety on foliage. Our tests show that it is less caustic than Paris green to foliage. We have not recommended it publicly because it is a dangerous thing to have the general run of farmers buying white arsenic and mixing and boiling it themselves. One has only to inspect the ordinary farmstead to see how careless the owner is about things which require careful handling and weighing. The refuse is thrown in the yard or into a stream. Utensils are left where they were used. There are farmers who are otherwise, and if they have much spraying to do, the white arsenic can be recommended confidently ; but I believe that most people should buy their poisons ready prepared, even if the cost is somewhat greater.

* * *

The San José scale is still with us. It will stay. There is no hope of eradicating it. Then every man should be prepared to meet it. He should not rely on State control alone.

For three seasons now, we have experimented with the kerosene and water emulsion—as others have done—and have found that it is a specific for the scale. In the proportion of 1 part of oil to 5 of water in summer, and 1 to 4 in winter, it will kill the scale.

Can a man hope to annihilate the scale, then, by spraying? No. On plants which he can spray thoroughly and frequently, he can hope to eradicate it; but I should not expect him to eradicate it from a large and badly infested plantation, any more than he can eradicate the apple-scab or the bark-louse. But I should expect him to keep it in check. Spraying for San José scale must come to be an accepted practice, as spraying for potato-blight is.

All this means that the farmer should not be frightened, but should be self-reliant and determined. But the State should help him. The law should not help him less, but more. Nursury stock should be fumigated with hydrocyanic acid gas, under strict control. It would be folly to attempt to burn every infested tree or bush wherever found; but the law should be so amended as to allow a properly qualified officer to destroy plants which, in the judgment of experts, are a menace to the general weal.

SUMMARY OF EXPERIMENTS OF 1899.

H. P. GOULD, S. W. FLETCHER AND G. W. CAVANAUGH.

I. The Season's Experience with the San José Scale.

The results of experiments in spraying for the San José scale were detailed in Bulletins 144 and 155. During the past year these experiments were continued more extensively. The former conclusions were fully confirmed. The infested stock was mainly apple, pear, plum, almond and willow trees, all of medium size or below. Some were very badly infested, but all had made a fairly vigorous growth in 1898. Experiments in 1898 had shown that a 20 per cent mechanical mixture of kerosene and water was the most efficient spray, so no other proportion was used this year. The first application in 1899 was made to one lot of trees on April 10 and 11, when the weather was favorable for rapid evaporation. This is a very important point in all spraying with un-emulsified kerosene. Another lot of trees was sprayed on June 6 and were, of course, in full leaf at the time of spraying. A few badly infested currant bushes were left as checks.

On June 23, the young scale insects were numerous on the unsprayed currants and a very few were found on the sprayed trees, indicating that the insecticide had killed most, but not all of the old scales. On one of the worst infested trees which had been sprayed, but a single live scale could be found. The trees sprayed in June showed more live scales than any of those sprayed in early spring.

All of the trees were sprayed a second time on June 24, and three with very dense heads again on June 29. At this date, Dec. 11, few live scales can be found on the sprayed trees—mostly on apples and pears, where some insects were protected from the spray by irregularities of the bark. On the smooth barked willows, every scale was killed. On the whole the results are encouraging. We feel sure that the San José scale can be held in check by spraying whenever the infested plants can be thoroughly treated. If the trees had been sprayed again in late summer, probably all the insects would have been eradicated; but it was desired to leave the trees for study.

While spraying for the San José scale in early spring has given excellent results, there is no reason why late fall spraying should not be equally effective, since the insect continues to multiply for some time after the leaves have fallen. Furthermore, it is often more convenient to spray in the fall than during the hurry of spring work. Summer spraying is rarely advisable, since the foliage prevents the insecticide from reaching all parts of the tree. We are now experimenting with early winter spraying for the scale.

Spraying vs. fumigating.—Most of the eastern fruit-growers and nurserymen who have adopted the fumigation method of combating the San José scale, report it efficient and practicable, when properly done. Fumigation is certainly more thorough than spraying. Hydrocyanic acid gas is very penetrating and can be depended upon to kill all the scales or other insects on the tree in one thorough fumigation, whereas several applications of the spray may be necessary to accomplish the same result. In spraying there is always a possibility that a few untouched insects may live and re-infest the tree. Nevertheless, there is no doubt but that the San José scale can be held in check by spraying.

The comparative cost of the two methods is a practical point. In spraying, a pump with a good kerosene attachment is the only equipment necessary besides the usual spraying appliances. In fumigation, tents are indespensible (if growing trees are treated) and are generally costly, especially those large enough to cover a full sized orchard tree. The choice between spraying and fumigation will therefore depend largely on the amount of work to be done and the first cost of the tents. Nurserymen will find fumigation the most effective and probably the most economical method of control, while those with growing plants will find kerosene spray an efficient, economical and simple method of checking the scale.

The San José scale situation is improving, not because the scale is less destructive but because it is better understood and methods of combating it are more generally known. In some respects it is undoubtedly the worst insect we have in the orchard. Every precaution should be taken to guard against infection; yet there is no reason why infested trees may not be saved, provided they are not seriously weakened before remedial measures are taken. Herein lies the greatest danger,—not because the insect is hard to kill, but because it is hard to see, and it spreads with amazing rapidity.. A slight infestation is not at all noticeable, and one must look sharp to see individual scales. The probability is that most farmers would not notice the San José scale on their trees till they are infested so badly as to be hardly worth the trouble of spraying. Taken at the right time, however, the pest can be dislodged. A faithful application of arsenical sprays will hardly save us 80 per cent of wormless apples; while the same amount of energy directed against the scale may be expected to hold it at bay.

II. FIELD TESTS OF NEW INSECTICIDES.

The burning of the foliage.—In order that an insecticide shall have practical value, it must not only check the insect or plant disease but must also work no injury to the plant itself. Many materials of great fungicidal value are worthless for practical purposes because they kill or injure the plant as well as the parasite. The standard insecticide is Paris green. As a poison it is very satisfactory; yet it is expensive, it does not remain long in suspension when applied with water, and it sometimes burns the foliage. These objections have induced several manufacturers to offer substitutes, a few of which this Station has tested in comparison with Paris green. Below is recorded the comparative injury to the foliage by four strengths of each insecticide. It is probable that much if not all of the injury noted could have been prevented by adding lime to the arsenical spray. The object of this test was merely to find out the physiological effect of the insecticides when used alone, and incidentally the danger limit of strength. Grades are recorded of injury ranging from doubtful (when the slight imperfections in the foliage may or may not have been produced by the spray), through slight, considerable, and severe to very severe (when a large proportion of the leaves had fallen and the young shoots were frequently killed). Most of the orchard applications were made June 10. The potatoes were sprayed July 10 and a duplicate lot on July 17. Final records on the fruit trees were taken July 1; on the potatoes, August 3. The spray barrel held 48 gallons.

TABLE I.—THE EFFECT OF INSECTICIDES ON FOLIAGE.

Insecticide.	Apple.	Pear.	Plum (domestic).	Peach.	Potato.
¼ lb. per bbl.					
Paris Green	none	none	none	doubtful	none
Paragrene	none	none	none	doubtful	none
Green Arsenite	none	none	none	slight	none
* XX	considerable	considerable	slight	very severe	severe
Pink Arsenoid	none	none	none	doubtful	none
Green Arsenoid	none	none	none	none	doubtful
Green Arsenoid, No. 53	slight	slight	doubtful	considerable	none
½ lb. per bbl.					
Paris Green	none	none	slight	slight	none
Paragrene	none	doubtful	slight	slight	none
Green Arsenite	none	none	doubtful	considerable	none
XX	severe	severe	considerable	very severe	very severe
Pink Arsenoid	none	none	considerable	considerable	none
Green Arsenoid	doubtful	doubtful	doubtful	severe	doubtful
Green Arsenoid, No. 53	slight	slight	severe	very severe	slight
† Arsenite of Lime	none	none	none	none	(no record)

* This insecticide was sent to us for trial under name; but since the manufacturers do not intend to place it upon the market in its present form, the name is suppressed. It is included in this report because it emphasizes certain undesirable features in the composition of an insecticide.

† One, two and three quarts of the material for the respective comparisons.

TABLE I.—*Continued.*

Insecticide.	Apple.	Pear.	Plum (domestic).	Peach.	Potato.
1 lb. per bbl.					
Paris Green	none	slight	slight	severe	
Paragrene	doubtful	doubtful	considerable	slight	
Green Arsenite	none	doubtful	doubtful	considerable	
* XX	severe	severe	very severe	very severe	
Pink Arsenoid	doubtful	doubtful	severe	severe	
Green Arsenoid	slight	doubtful	slight	severe	
Green Arsenoid No. 53	considerable	slight	very severe	very severe	
Arsenite of Lime	none	none	doubtful	doubtful	
1½ lbs. per bbl.					
Paris Green	none	slight	slight	very severe	
Paragrene	doubtful	slight	considerable	very severe	
Green Arsenite	none	slight	slight	severe	
* XX	severe	severe	very severe	very severe	
Pink Arsenoid	slight	slight	severe	very severe	
Green Arsenoid	severe	doubtful	considerable	very severe	
Green Arsenoid No. 53	severe	considerable	very severe	very severe	
Arsenite of Lime	none	none	doubtful	slight	

A bug-killing contest.—A test of the insecticidal value of these materials was made on potatoes. The results are fairly representative of their value as insecticides, for if the materials will kill potato slugs their poisonous properties are assured.

Two strengths of the materials were used: ¼ lb. per bbl., (48 gals.) the strength at which Paris green is usually applied for potato slugs, and ½ lb. per bbl. The spraying was done July 10 and 17, each strength covering about seventy-five rods of rows. The physiological effects of the arsenites are recorded in Table I. Slugs were not numerous, but were plentiful enough for a fair test. Both strengths of Paris green, Paragrene, XX, and Green Arsenoid killed all the slugs. A very few sick ones were found when both strengths of Pink Arsenoid, Green Arsenoid No. 53 and Green Arsenite had been sprayed, yet it would pass for a clean sweep.

III. THE COMPOSITION OF ARSENITES.

The analyses of the insecticides used in these experiments consisted chiefly in determining the amount of arsenic, the arsenic soluble in water, and the copper. The arsenic soluble in water was found by shaking the insecticide in water for one hour, at the rate of one pound to one-hundred gallons, and determining the amount of arsenic dissolved. Comparing Table II with Table I it will be seen that in proportion as the amount of soluble arsenic in an insecticide increases, its injury to foliage likewise becomes greater. At the rate arsenites are commonly used (¼ lb. per bbl.), the burning is not noticeable with insecticides having less than 3 ½ per cent of soluble arsenic.

Anybody but a chemist is likely to become confused over the nomenclature of poisons. *Arsenite* is a general term for all compounds of arsenious oxid ($As_2 O_3$), the active element in all these materials. *Arsenoid* is a trade name, not a chemical compound, and simply means arsenic-like. An *arsenate* is a compound of arsenic acid ($As_2 O_5$). None of the materials mentioned here is an arsenate. When the term arsenic is used in connection with insecticides, we mean what is ordinarily called white arsenic ($As_2 O_3$) and not the metal arsenic (As). In the table copper is given as copper oxid (Cu O), lead as lead oxid (Pb O) and lime as calcium oxid (Ca O). The sulfuric acid ($S O_3$) has no insecticidal effect.

TABLE II.

ANALYSES OF ARSENITES.

Insecticide.	As_2O_3 Arsenic, total.	As_2O_3 Arsenic, soluble.	CuO Copper oxid.	SO_3 Sulfuric acid.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Paris green	56.45	1.83	23.62	.71
Paragrene	55.57	3.21	27.68	1.34
Green arsenite	54.10	2.36	31.59	3.70
XX	33.71	32.23		
Pink arsenoid	49.17	1.93	49.09 (PbO)	
Green arsenoid	60.63	3.53	29.29	1.55
Green arsenoid No.53	53.71	8.33	29.43	3.70

In Bulletin 149, page 720, the following analysis of Laurel green was published:

Copper (Cu)	10.00 per cent.
Arsenic (As_2O_3)	7.75 "

This year an insecticide manufactured by the same firm and labeled Special Laurel green analyzed:

Arsenic (As_2O_3) total	42.69 per cent.
" " soluble	1.15 "
Copper oxid (CuO)	4.50 "
Lime (CaO)	35.39 "

With its present composition this material evidently has value as an insecticide, although no field tests have been made here. It is manufactured by the Nichols Chemical Company of New York, and retails for 12½ cents per pound.

Heretofore the ammonia test has been advised for detecting the purity of Paris green. The pure Paris green which has been on the market in the past does dissolve in ammonia completely; but this year samples have been received for analysis which do not, although containing the 50 per cent of arsenic required by New York State law. The reason is that they contain lime as well as copper, and the lime compound with arsenic is insoluble in ammonia water. Although this material is a good insecticide, it is not Paris green.

The specific gravity of insecticides.—An important point in every insecticide applied with water is the time it will remain in suspension. If the arsenite sinks to the bottom of the barrel in a few minutes, as does Paris green, there is an unequal distribution of the poison and the concentrated mixture at the bottom is likely to burn the foliage. Frequent stirring is an inconvenience. Generally speaking, the lighter and more flocculent an insecticide is, the longer it will stay in suspension. Assuming the Paris green to be 10, the various insecticides compare with it in weight as follows: Green Arsenite, 10; Pink Arsenoid, 9; Paragrene, 7; Green Arsenoid, 7; XX, 4; Green Arsenoid No. 53, 4. Equal amounts of the above arsenites shaken in water followed approximately the same order in settling, Paris green and Green Arsenite settling first, and No. 53 last. The heavy specific gravity of Paris green is one of its weak points as an insecticide.

Summary on insecticides.—*Paragrene.*—Manufactured by Fred L. Lavenburg, New York. Price 14½ cents per pound in 14 pound pail. It has equal insecticidal value with Paris green, is about as likely to burn the foilage and remains longer in suspension. We consider it an excellent substitute.

Green arsenite. — (Arseniate of copper, Scheele's green.) This is practically the same as Paris green in composition, and has the same effect on foliage. Its fungicidal value is slightly greater than Paris green owing to the higher percentage of copper oxid. When it can be obtained as cheaply as Paris green, it may be given preference.

Pink arsenoid. — Manufactured by the Adler Color and Chemical Works, Brooklyn, N. Y. Retail price, 15 cents per pound at N. Y., f. o. b. It is slightly inferior to Paris green as an insecticide and has decidedly less fungicidal value, since the lead oxid it contains, corresponding to the copper oxid of Paris green, has little if any merit as a fungicide. The pink color may be objectionable. Paris green has been so long in common use that people instinctively associate an arsenical poison with a green color. This material is apparently not as valuable as the following, manufactured by the same firm.

Green arsenoid.—Retails for 15 cents per pound f. o. b. It is slightly superior to Paris green in composition and appears to be equally safe on foliage when applied at the ordinary strength. The powder is more flocculent than Paris green, about a third lighter and remains correspondingly longer in suspension. With its present composition and price we feel justified in recommending it for practical use.

Green arsenoid No. 53.—The most serious objection to this material is that its comparatively high percentage of soluble arsenic makes it liable to burn the foliage. It is about equal to Paris green in insecticidal value, superior to it as a fungicide and is remarkably slow in settling from a spraying mixture. Provided the soluble arsenic were neutralized with lime, No. 53 would make an efficient and economical substitute for Paris green.

Arsenite of lime.—This has the three-fold advantage of being cheap, the amount of arsenic is under perfect control, and it does not burn the foliage. It is made by boiling together for forty-five minutes

1 pound white arsenic.
2 pounds fresh lime.
1 gallon water.

This may be kept in a tight vessel and used as desired. Thoroughly stir the material before using. For most insects, one quart of the above per barrel will be sufficient. Arsenite of lime is insoluble in water and will not injure the foliage of any orchard fruit at this strength. This insecticide is growing in popularity. Some green dye stuff should be mixed with it to prevent the ever-present danger of mistaking it for some other material.

IV. THE BURNING OF FOLIAGE BY FUNGICIDES.

The effect on Japanese plums.—The foliage of the Japanese plums is so extremely sensitive to injury from fungicides and insecticides that one must always be cautious when spraying this class of fruit. The apparently increasing susceptibility of the Japanese plums to the fruit rot (Monilia) makes it essential to take some preventive measure. It cannot be said that spraying is always an absolute specific for the fruit rot. In a wet season, no advantage may be noted. Through a series of years, however, a faithful combination of spraying, thinning the fruit and destroying the diseased fruit can be depended upon to prevent serious injury.

The standard fungicide for the Japanese plums is Bordeaux mixture. Bulletin 164 contains an account of the shot-hole effect produced by Bordeaux on plums and peaches. This injury has been observed for several years as resulting from even the most carefully prepared Bordeaux. During the past season, experiments were made to determine the effect of copper carbonate and potassium sulfide on Japanese plum foliage. The copper carbonate was applied in an ammoniacal solution at the usual strength: the potassium sulfide at the rate of one ounce to a gallon of water. Both were slightly more injurious to the foliage than Bordeaux. Since it is not probable that either has a greater fungicidal value than Bordeaux, there can be no advantage in displacing the older fungicide.

The effect of copper sulfate on foliage.—It would be difficult to find a material of greater fungicidal value than Bordeaux mixture, yet it becomes a practical point to combine the same efficiency with greater ease in application and less danger of injury to the foliage. Those who have used a solution of copper sulfate find it to be an excellent fungicide. From laboratory studies we know that a very weak solution of blue vitriol will prevent the germination of fungi spores, but it is a question if it will have the same value under the conditions of orchard and field.

It is of importance to know whether the foliage will be injured by a solution strong enough to be an efficient fungicide. The spraying in our test of this point was done May 24, and the final records taken June 10. The barrel reported below holds 48 gallons.

TABLE III.

INJURY TO FOLIAGE FROM COPPER SULFATE SPRAYS.

Foliage.	4 oz. per bbl.	8 oz. per bbl.	1 lb. per bbl.	2 lb. per bbl.
Apple	doubtful	slight	considerable	considerable
Pear	doubtful	slight	severe	very severe
Peach	considerable	considerable	severe	very severe
Cherry	none	slight	slight	severe
Plum (domestic)	considerable	considerable	severe	very severe
Plum (native)	slight	slight	considerable	considerable
Plum (Japan)	considerable	considerable	severe	very severe

Although no severe injury to the native plums is recorded in the table, it was incidentally brought out that there is considerable variation between the different varieties of this group in their susceptibility to injury. The variety under experiment was Golden Beauty. Some spray accidentally reached the leaves of an adjacent Munson and there caused serious injury.

Most of the injury noted was in the spotting of the leaves. Wherever the fungicide clung, there the tissue was killed and ultimately fell out, producing a condition which might readily be mistaken for the effect of the shot-hole fungus. When copper sulfate was applied to peaches and domestic plums at the rate of 2 lbs. per bbl., these perforations were so numerous that many leaves dropped. The young fruits of the Japanese plums were injured by the two strongest sprays.

These tests do not throw any light on the value of copper sulfate for controlling plant diseases; they simply indicate that unless careful discrimination is made between varieties, only a very weak solution can be used with safety to the foliage. Until the simple solution of copper sulfate has been tested further, there is no safer or surer orchard fungicide than well made Bordeaux mixture. On Japanese plums, apply it weak. It would be well to experiment in applying it only in bright weather.

VARIOUS POINTS.

1. The San José scale can be controlled in a plantation by a 20 per cent kerosene and water mixture when the plant is thoroughly sprayed. Early spring or late fall spraying is preferable, but the material may be applied when the plant is in full leaf if the day is sunshiny.

2. Only on sunshiny days should sprays of kerosene and water be used.

3. Compared with fumigation on growing trees, spraying is cheaper, simpler, and perhaps equally effective in the long run. Nurserymen will find fumigation better adapted to their needs than spraying. On growing plants, however, it is attended with difficulty because of the necessity of providing tents.

4. Paragrene, green arsenite, green arsenoid and arsenite of lime are equal if not superior to Paris green in insecticidal value. The reduced price of these substitutes will commend them. Arsenite of lime can be made at home.

5. Bordeaux mixture is liable to injure the foliage of the Japanese plums, but no better fungicide for spraying this class of fruit is now known. To avoid injury, use a very dilute mixture.

6. Varieties of fruit differ in their susceptibility to injury from sprays.

7. Unless lime is added, a simple solution of copper sulfate as strong as 4 ounces per barrel, cannot be used without injury to the foliage of many fruit trees.

The Following Bulletins are Available for Distribution to Those Who May Desire Them.

40 Removing Tassels from Corn, 9 pp.
55 Greenhouse Notes, 31 pp.
71 Apricot Growing in Western New York, 26 pp.
72 The Cultivation of Orchards, 22 pp.
74 Impressions of the Peach Industry in N. Y., 28 pp.
75 Peach Yellows, 20 pp.
76 Some Grape Troubles in Western N. Y., 116 pp
78 The Cabbage Root Maggot, 99 pp.
79 Varieties of Strawberry Leaf Blight, 26 pp.
80 The Quince in Western N. Y., 27 pp.
93 Cigar-Case-Bearer, 20 pp.
95 Winter Muskmelons, 20 pp.
96 Forcing House Miscellanies, 43 pp.
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121 Suggestions for Planting Shrubbery.
122 Second Report upon Extension Work in Horticulture, 36 pp.
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124 The Pistol-Case-Bearer in Western New York, 18 pp.
125 A Disease of Currant Canes, 20 pp.
126 The Currant-Stem Girdler and the Raspberry-Cane Maggot, 22 pp.
127 A Second Account of Sweet Peas, 35 pp.
128 A Talk about Dahlias, 40 pp.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
130 Potato Culture, 15 pp.
131 Notes upon Plums for Western New York, 31 pp.
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144 Suggestions on Spraying and on the San José Scale.
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146 Fourth Report of Progress on Extension Work, 26 pp.
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149 Some Spraying Mixtures.
150 Tuberculosis in Cattle and its Control.
151 Gravity or Dilution Separators.
152 Studies in Milk Secretion.
153 Impressions of Fruit-Growing Industries.
154 Table for Computing Rations for Farm Animals.
155 Second Report on the San Jose Scale.
156 Third Report on Potato Culture.
157 Grape-vine Flee-beetle.
158 Source of Gas and Taint Producing Bacteria in Cheese Curd.
159 An Effort to Help the Farmer.
160 Hints on Rural School Grounds.
161 Annual Flowers.
162 The Period of Gestation in Cows.
163 Three Important Fungous Diseases of the Sugar Beet
164 Peach Leaf-Curl.
165 Ropiness in Milk and Cream.
166 Sugar Beet Investigations for 1898.
167 The Construction of the Stave Silo.
168 Studies and Illustrations of Mushrooms: II.
169 Studies in Milk Secretion.
170 Tent Caterpillars.
171 Concerning Patents on Gravity or Dilution Separators.

Bulletins Issued Since the Close of the Fiscal Year, June 30, 1899.

171. Gravity or Dilution Separators.
172. The Cherry Fruit-Fly: A New Cherry Pest.
173. The Relation of Food to Milk-Fat.
174. The Problem of Impoverished Lands.
175. Fourth Report on Japanese Plums.
176. The Peach-Tree Borer.
177. Spraying Notes.

UNIV. OF MICH.
MAR 17 190

Bulletin 179. [redacted].

Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

CHEMICAL DIVISION.

INTRODUCTION TO

Field Experiments with Fertilizers.

59.—*Results of thorough and hasty preparation—Buckwheat.*

By A. L. KNISELY.

PUBLISHED BY THE UNIVERSITY
ITHACA, N. Y.
1900.

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* Absent on leave.

CORNELL UNIVERSITY, ITHACA, N. Y., February 1, 1900.
HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

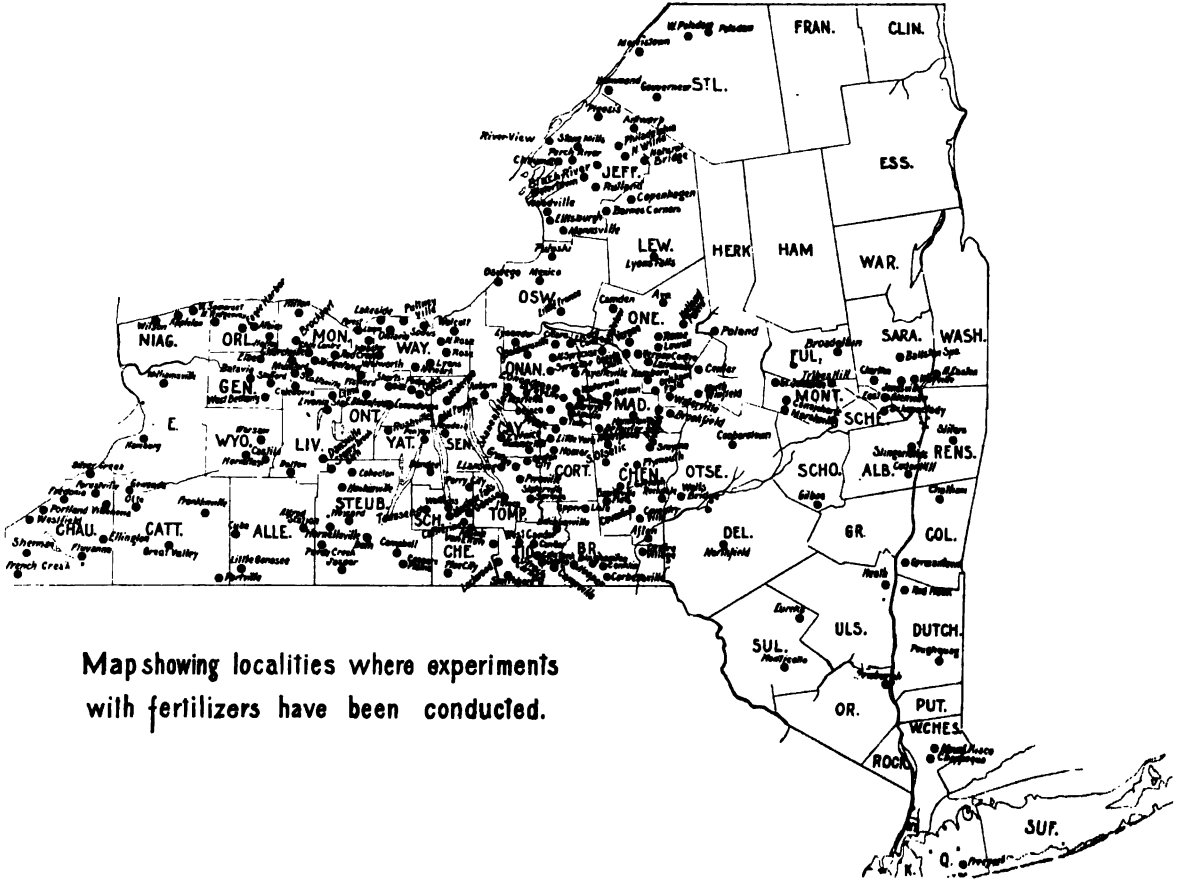
Sir: It cannot be denied that the use of commercial fertilizers is a source of profit for the farmer, when they are used in the right way. But the common way of using them is not the right way. The application of a complete fertilizer, without knowing whether the crop to be fertilized needs the three plant-foods, or whether the yield may not be just as large, if but one, or perhaps two of them are supplied, usually results in waste.

The purpose of the field experiments with commercial fertilizers, an account of which is given in part in this bulletin was to interest farmers in testing their soils in order that they might learn what plant-food is deficient for the crops that they wish to raise, and also whether the commercial fertilizers used are more or less profitable than good stable manure.

The results of these experiments have taught many farmers that they have not been using these fertilizers in the right way; this work has also taught them how to experiment. To Dr. G. C. Caldwell, Chemist of the Experiment Station, much credit is due for having inaugurated this plan of conducting field experiments. The work has been made especially effective by the zeal with which the author of this bulletin has superintended the experiments during the three years of their continuance. In his visits to a large number of the farms where experiments were being carried on he helped and encouraged the experimenters by his valuable criticisms and suggestions.

It is hoped that this work can be continued during the present year.

I. P. ROBERTS, Director.



Map showing localities where experiments with fertilizers have been conducted.

INTRODUCTION TO

FIELD EXPERIMENTS WITH FERTILIZERS.

A difficult problem.—Some of the questions most frequently asked by farmers are these: What fertilizer shall I use on my land? How can I tell just what combination or mixture of plant-foods is best adapted to my soils? What is the best all round fertilizer? Such questions are among the hardest that can be asked in the whole field of agriculture. They cannot be answered offhand in a day or a week; it may take months and in some cases years to answer them. Many a farmer spends his whole life on the farm without even trying to solve these problems, or without getting correct answers if he does try to solve them.

What regulates crop production.—A farmer grows an acre of corn and harvests a modest crop of 10 bushels. What is the cause of this very poor yield? Something must be wrong and it is for him to try and find out wherein the trouble lies. The poor yield may be due to one or more of several conditions. It may be a lack of moisture, or too much moisture; the soil may be too acid; it may be deficient in either nitrogen, phosphoric acid or potash; it may be too cold and heavy; it may not contain enough nitrifying organisms to maintain a good supply of nitrates or it may contain too many denitrifying organisms which destroy nitrates; it may be too compact and therefore may not leave enough air spaces between the soil particles; capillary action may be imperfect; there may be a lack of humus; the texture may not be suitable to the crop grown; and so on.

The law of the minimum.—This is most important with reference to plant growth. It means that the one essential condition which is at a minimum, or is at the lowest grade, during the growth of a crop, is the one condition that regulates the amount of crop grown.

For example, a field may have all the essential conditions favorable for producing a large crop, except one. Let that one be a lack of available phosphoric acid, then the amount of crop grown is regulated by the amount of available phosphoric acid present. If this quantity is increased, the crop will be increased. To apply nitrogen or potash to this soil would be unwise for it may be taken for granted that these plant-foods are already present in sufficient quantity for at least a fair crop. Again, suppose that the essential condition which is at a minimum is a lack of humus, or it may be an unsuitable texture. Then the total crop produced will be governed by the amount of humus or by the texture. If the amount of humus in the soil is increased or if the texture is improved then this soil becomes more productive. An application of commercial fertilizers to such a field would have little or no beneficial effect.

It sometimes happens that some essential condition is at such a low grade, and is of such a character that the farmer can recognize it at a glance; for instance, a soil may be a very stiff, hard, compact clay, similar to a brickyard. Such a soil must be loosened and made porous and friable or mellow. Its texture must be improved before one could expect to obtain profitable results from the use of fertilizers. But if the farmer wants to make the most that he can out of his farm he will not stop here; for just as soon as one low-grade condition has been improved and larger crops are thereby obtained, some other condition may be at a minimum and consequently regulates the amount of crop produced. This becomes the condition to be sought out and improved in order that the productivity of the soil may be raised to a higher standard.

These essential conditions may be likened to a lot of jackscrews and the productivity or fertility of the field to a large house. If we wish to raise this house, we distribute the jackscrews in various places under it. If the house is to be raised without damage, every one of these jackscrews must be carefully watched and that one which is the lowest must be screwed up; presently some other screw becomes the lowest and that one in turn must be attended to and so on with every one of the supports.

If all the screws are carefully watched the house rises properly; if only a part are watched and no attention is paid to the others, before long something is liable to be strained and the house may be badly injured. So it is with the fertility of a soil: each and every one of the many conditions essential for raising a large crop must be carefully watched: those which are constantly falling short in consequence of the improvement of the others must themselves be likewise improved in order to keep the fertility up to its maximum. If only a few of the essential conditions are looked after, the soil will in time become less productive and the farmer becomes discouraged and sums up the whole difficulty by saying, "Farming don't pay." On the other hand, a successful, wide-awake farmer is constantly trying to find out, and does detect and improve those conditions of his soil which are at the lowest ebb, and to him farming *does* pay.

Take for another illustration an actual case in which an important condition, namely capillary action, was at a low grade. Two adjacent fields were prepared for buckwheat; the same seed was used on each field, it was sown at the same rate per acre and with the same drill. Similar fertilizers were applied to each field; the amount applied and the manner of applying them were the same. For the results see the frontispiece.

The only known difference between the two fields was this; one was thoroughly prepared, the other was prepared in a hurry. The thoroughly prepared field was plowed in advance of planting-time and the soil had settled somewhat, so that its capillary action had time to re-adjust itself and was able to pump up moisture from below to keep the seed-bed damp; consequently the buckwheat sprouted promptly and grew luxuriantly thereafter.

The hastily prepared field was plowed just before the buckwheat was sown. The capillary action was broken up and did not have time to re-adjust itself, consequently the moisture from below could not rise to the seed-bed. The surface soil soon became dry and the buckwheat grew very slowly owing to the lack of moisture in the uppermost few inches of the arable layer.

This season the author's attention was called to another interesting case. A farmer planning to sow buckwheat started an early preparation of the soil. The headlands were plowed and also a narrow strip across the field, before night came on. Plowing could not be finished, however, until planting-time. Then the work was done hastily on the remainder of the field and the seed was sown. The results were that the headlands and the narrow strip across the field that were plowed early, and had re-adjusted the capillary action before planting-time, yielded a large crop that even lodged considerably. The rest of the field was scarcely worth harvesting.

The object of the experimental work.—This work was undertaken for the purpose of helping the farmers of the State to detect and improve some of the low-grade conditions of their fields. Experimental work with fertilizers, which is the subject of this bulletin, was taken up. It was the plan of the Station to send to such farmers as would agree to do the work, a sufficient quantity of the three plant-foods, nitrogen, phosphoric acid and potash, separately and in combination, with directions for a series of experiments for the purpose of determining whether any separate plant-food or any combination of them would increase the crops to which they were applied. The results of such experiments, carried out according to directions, should assist the farmer to decide what plant-foods his soils need, if any, for the production of satisfactory crops.

If the series of experiments proves to be a failure, that is, if it gives no marked or definite results, it is still valuable. It at least shows the farmer that his soil is not in a condition to respond to the use of fertilizers, which means either that it is already well stocked with available food or that some one or more of the essential conditions other than plant-food conditions need looking after and improving before much money or time is spent on fertilizers.

Extent of the experimental work and the results in general.—During the past three years 371 sets of fertilizers have been sent to farmers in various parts of the State. (See map, page 286.) The time at which the appropriation for this work became available in the spring was so far advanced, that in some cases the fertilizers were received by the farmers much later than they should have been applied to the soil; the results may therefore have been less satisfactory than might otherwise have been the case.

A majority of the experimenters have been visited by a Station representative ; in some cases photographs of the crops have been taken ; in other cases samples of soil have been sent to the Station for analysis. In general the farmers manifested much interest in the work and most of them took great pains with it. A few were disappointed because it required so much "time and fussing." Of all the experimenters only one failed entirely to catch the spirit of the work ; owing to some misunderstanding he dumped the small sacks of fertilizers into a tub, mixed them together, and applied the mixture on a small plat of land. He reported that he thought the fertilizer increased the crop somewhat—a report of no use to him or to us.

A number of the experimenters made the mistake of measuring off too small plats and consequently the fertilizers in some cases injured the crop. A large number did the work well and kept good records, but many of them unfortunately omitted the check plat without fertilizers. This plat was absolutely necessary as a standard for the measuring of the crops grown on the several fertilized plats. Without it the results obtained on the fertilized plats were almost worthless for the experimenter ; he could not decide whether or not any of the fertilizers had inceased the yields, or whether any one gave a profitable crop. However, notwithstanding all these unfortunate drawbacks there were many experimenters who followed all the directions and felt that they had profited by the work.

In 1897 and again in 1898, fertilizers were used at the rate of 200 lbs. of nitrate of soda, 400 lbs. of superphosphate and 200 lbs. of muriate of potash per acre. Owing to the prevalence of acid soils, in 1898 it was advised to use lime when convenient, on half of each plat at the rate of two tons per acre. In 1899 the application of fertilizers was increased to 300 lbs. of nitrate of soda, 600 lbs. of superphosphate and 300 lbs. of muriate of potash per acre.

Acid soils.—Within the last few years the subject of acid soils has been brought to the attention of farmers and questions are frequently asked about this acidity or sourness of soils. While traveling about the State, the Station representative had exceptional opportunity for testing various soils for acidity; the tests were made by leaving blue litmus-paper in contact with the moist soil for five minutes. The presence of acid in the soil would be indicated by a reddening of the paper. One hundred and eighty-six tests were made in different parts of the State; of these, 160 indicated the presence of considerable acidity. Generally, the most acid soils were found to be uplands, usually sandy or light clay loams and especially soils underlaid with hardpan. In several cases low-lying, wet, muck soils were tested and were found to be free from acid.

Acid soils must not always be associated with poor crops. Some acid soils produce very poor crops, others luxuriant crops. The most thrifty cornfield seen during the season was growing on very acid or sour soil. The same was also true with potatoes. Experiments show that both corn and potatoes are not affected by acid in the soil. Potatoes grown on acid soil were better, smoother, less scabby and diseased than those grown on soil not acid. Many clover fields were tested and most of them showed acid, but usually the best fields would have the least acidity. Generally, common plantain and sorrel would be sure indications of free acid in the soil.

Was the use of lime beneficial?—Since the presence of acid in the soil was found to be so common, it was thought best to try the use of lime for correcting this acidity; it was applied at the rate of two tons per acre, in some cases quicklime slaked on the field, in others air-slaked lime. Thirty-one field tests were thus made. Several months after this application these soils were found to be just about as acid, producing the same change of the litmus-paper as the adjacent soils which had not been limed. The use of lime by itself gave very good results in seven cases, injurious results in three cases, and indifferent results in twenty-one cases. When used in connection with fertilizers, the results were in five cases very good, in four injurious, and in twenty-two indifferent. In two cases the use of lime was followed by an injurious effect upon the physical condition of the soil, consisting of clay loams, tending to make them hard and lumpy, rather than loose and friable.

That the use of lime was not more often followed by marked favorable results may be due to the fact that the application was not large enough, or that it had not in that short time become thoroughly mixed in the soil. Its use is worth further trial and more serious study.

Circular of instructions.—In 1898 and '99 a special circular of instruction was sent to each farmer who was carrying on experimental work with fertilizers.

The following is one of the circulars which was sent out in the spring of '99 and returned in the fall. Spaces were left for recording the summer's work and these were filled out by the experimenter according to the directions. That part of the circular printed in italics constitutes the actual report of the experimenter.

CIRCULAR OF INSTRUCTIONS
CONCERNING
FIELD EXPERIMENTS
WITH
FERTILIZERS

No. 14.

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION.
I. P. ROBERTS, DIRECTOR.

ITHACA, N. Y., April, 1899.

DEAR SIR:

We have ordered one set of fertilizers to be sent to you by freight. This set consists of two large sacks containing four 15 lb. sacks of nitrate of soda; two 15 lb. sacks of muriate of potash; two 30 lb. sacks of superphosphate, and two 45 lb. sacks containing a mixture of 30 lbs. of superphosphate and 15 lbs. of muriate of potash.

We have also sent you a revised copy of Bulletin 129 of this Station. It contains many valuable suggestions about conducting field experiments with fertilizers.

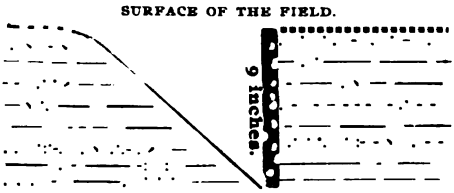
Circular No. 14 explains how to apply the fertilizers and how to keep a record of the season's work.

KEEP THIS CIRCULAR IN A HANDY PLACE AND FROM TIME TO TIME JOT DOWN NOTES UNDER THEIR PROPER HEADINGS. FINALLY IN THE FALL RECORD THE WEIGHTS OF CROP GROWN ON EACH PLAT AND THEN RETURN THIS SAME CIRCULAR TO G. C. CALDWELL, ITHACA, N. Y.

Do not get this experimental work confused with another line of investigations with sugar beets which the Station is planning.

SAMPLING THE SOIL.

The first thing to do before applying the fertilizer is to get a good average sample of soil from that portion of the field on which the plats are laid out.



Proceed as follows: with a spade with a square end dig a hole, the width of the spade and nine inches deep, leaving one side of the hole vertical and the other side sloping just as in the cut. Clean out all the loose soil at the bottom of the hole; cut off from the vertical side a slice about two inches thick from top to bottom, the full width of the spade; this slice represents one of the partial samples; in precisely the same manner take 10 to 15 other samples from different parts of the field.

Put all the samples together, after having picked out of each one all pebbles over ¼ to ½ inch in diameter. In a clean box large enough to hold them all, or on some clean boards, mix the samples together as thoroughly as possible, by stirring and shoveling over and over many times; then put four or five pecks of this mixture into a strong sack, or into a box about large enough to hold it, and tie the sack, or cover the box tightly. The sack in which the fertilizers were sent must not be used for this purpose. Too much care cannot be taken in preparing this sample so that it shall represent the soil of the whole larger plat to be divided up into smaller ones for the experiments.

Make a record of the field, as complete as possible, according to the following plan:

I—Location of Field.
  a—Upland.
  b—Lowland. (If lowland, do sidehills wash down upon it?)
  c—Hillside, etc.

Write answer here—*The field was valley land and laid up towards the hills. The sidehill did not wash down on it.*

II—Character of Soil.
- a—Sandy.
- b—Gravelly.
- c—Clayey.
- d—Loamy, etc.
- e—How deep is surface soil?
- f—Is there a hardpan; if so how deep is it?
- g—Does soil hold moisture, or dry out rapidly?

Write answer here—*The soil was dark loam and a little gravelly. The surface was from 10 to 12 inches deep with no hardpan and rather inclined to hold the moisture.*

III—Fertility of Soil.
- a—Does the soil possess the required amount of plant-food, or does it "run down" quickly and need enriching?
- b—Have manures or fertilizers been applied in past years? If so, how often, what kinds and how much per acre?

Write answer here—*The soil possessed a good amount of plant-food and does not run down easily. It has been manured about once in 4 years, generally 20 tons per acre previous to raising a crop of corn in rotation.*

IV—History of Crops Previous to 1899.

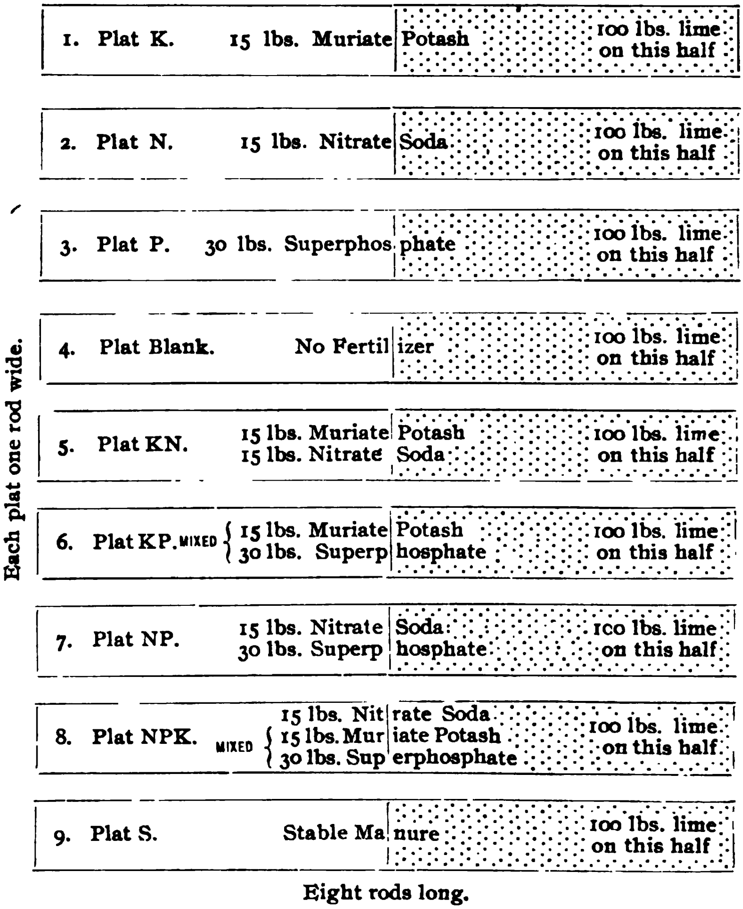
What crops have been grown and how much yield per acre, in past years? In case of cereals give the number of bushels of grain and tons of straw or stalks per acre.

Write answer here—*Had raised in past years a rotation of hay, two years yielding from 2 to 4 tons per acre; then manured for corn or potatoes, either yielding good crops—corn 125 bu. ears per acre, or potatoes 100 to 200 bu. per acre. This followed with oats, yielding from 40 to 60 bu. per acre with a large growth of straw; this completed the rotation. This year the potatoes were raised after corn which had been manured.*

The field should be plowed before the plats are laid out. Then use good, substantial stakes at the corners of the plats, and mark them in such a way that the plats will not become mixed, thus leading to confusion. It would be well to leave a space of 4 ft. between each two plats in order to be sure that the plants on one plat cannot feed on the fertilizer each side of it.

Do not lay out the plats on land that has been manured within one year. If you carried on fertilizer experiments last year do not use the same set of plats again this season.

The following diagram shows the arrangement of the plats, with the spaces between. Each plat contains $\frac{1}{20}$ of an acre.


1. Plat K. 15 lbs. Muriate Potash
2. Plat N. 15 lbs. Nitrate Soda
3. Plat P. 30 lbs. Superphosphate
4. Plat Blank. No Fertilizer
5. Plat KN. 15 lbs. Muriate Potash 15 lbs. Nitrate Soda
6. Plat KP. MIXED 15 lbs. Muriate Potash 30 lbs. Superphosphate
7. Plat NP. 15 lbs. Nitrate Soda 30 lbs. Superphosphate
8. Plat NPK. MIXED 15 lbs. Nitrate Soda 15 lbs. Muriate Potash 30 lbs. Superphosphate
9. Plat S. Stable Manure
100 lbs. lime on this half
Each plat one rod wide.
Eight rods long.

THE USE OF LIME.

Some recent investigations that have been carried on under the direction of Mr. Wheeler of the Rhode Island Experiment Station, at Kingston, R. I., have shown that acidity or sourness of the soil is much more common than has hitherto been supposed to be the case. It was proved by these experiments that this acidity of the soil lessens the effect of fertilizers on very many crops; in most cases the effect of nitrate of soda was very much lessened.

It is for this reason that the use of lime is recommended in the experiments of this year, when it can be obtained without too much cost, on half of each one of the small plats of the set, in the manner directed below.

If the soil is acid or sour, the lime corrects the acidity, and makes success with fertilizers much more certain; besides this it loosens a heavy clay loam, so that it can be more easily cultivated; it helps in the conversion of the slow action of the nitrogen of the soil into more rapid action; it may set free and make immediately efficient some of the tightly locked potash of the soil.

The experiments of last year indicated that the failures to get good crops with the fertilizers applied was not due to a ack of plant-food in some of the soils tested; it is quite possible that if lime had been used with the fertilizers better results would have been obtained.

One application of lime will last for some years. Therefore, since its use may prove to be profitable in many cases, a trial of it seems to us advisable.

APPLICATION OF THE LIME AND FERTILIZERS.

Each half plat is to receive 100 lbs. of lime.* (One heaping bushel of fresh stone lime weighs 75 lbs.; one heaping bushel of air-slaked lime weighs 50 lbs.—Roberts' Fertility of the Land, page 305.)

The plats having been laid out, make two piles of fresh stone lime of 50 lbs. each (⅔ bushel in each pile) upon that half of each plat which is to be limed. This quantity represents two tons of lime per acre. Pour from ¼ to ½ of an ordinary pailful of water on each pile of lime, or less water if the soil is pretty damp, and immediately cover the lime with soil. In three or four days the lime will be completely slaked. It is then in the form of a fine, white powder, and it can be easily spread. With a shovel scatter the lime in the two piles as evenly as possible over that half of the plat to be limed; care should be taken not to leave an excessive amount of lime on the ground under the piles. If fresh stone lime cannot be obtained, use air-slaked lime if that can be had. The air-slaked lime is already in the form of a fine powder and should be spread broadcast immediately without further treatment; (2 bushels to each half plat if air-slaked lime is used.)

Apply the lime as early in the spring as possible on the PLOWED GROUND and immediately drag it into the soil most thoroughly.

As soon as this work has been done, apply broadcast the muriate of potash and superphosphate to the whole of each plat which is to be manured with one or the other, or with a mixture of the two, and drag into the soil as thoroughly as possible. Drag the plats lengthwise because particular care must be taken that none of the fertilizer for one plat is sown on or is dragged on another plat adjoining it. In many cases muriate of potash injures the plant if applied just previous to putting in a crop; so that the earlier this fertilizer is applied in the spring the less will be the danger of injury.

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*If potatoes are to be grown on the plats, omit the use of lime.

Apply half the nitrate of soda broadcast on the whole of each plat requiring it just before the seed is planted and drag into the soil. Three weeks later apply the rest and cultivate in.

Care should be taken to keep the nitrate off the foliage of plants, as it may cause some damage ; in the case of sown crops, such as oats, it will be impossible to prevent this altogether.

BE SURE NOT TO OMIT THE BLANK OR CHECK PLAT WITH NO FERTILIZER. This is the most important of any single plat because all of the others must be compared with the blank in order to learn how much benefit the fertilizers have been to the crop.

You are to grow any crop you wish on these plats.

The same kind and same amount of seed is to be sown on each of the series of nine plats in the set. It must be remembered that these experiments are to be tried upon the crop planted and not upon an accidental crop of weeds. In no case will the experiments be of value if the weeds are allowed to grow on the plats. Thorough cultivation is one of the most important features of the field test.

RECORDS FOR 1899—TO BE FILLED OUT.

1—Date of plowing field. *May 2.*

2—Date of applying lime. *No lime used.*

Was the lime fresh slaked, or air-slaked?

Date when dragged into soil.

Dragged how many times?

3—Date of applying muriate and superphosphate. *May 15.*

Date when dragged into soil. *May 15.*

Dragged how many times? *Three times.*

Date of applying first half nitrate of soda. *May 15.*

Date of applying second half nitrate of soda.

4—Kind of crop grown. *Rural New Yorker Potatoes.*

5—Date of planting crop. *May 15.*

Dates when crops came up on each plat. *June 5—Could see no difference in the plats as to time they came up.*

6—Dates of rain storms and general remarks on weather. *Very dry from June 1st to 15th. Good rain June 15th and June 24th. Showers June 28th then very dry up to July 6th. Plenty of rain from July 6th to July 20th, then very dry. No more rain to speak of till after the potatoes were matured and dug.*

7—Dates of cultivating plats. *With a Hallock Weeder—May 20th, 23d, 25th, 28th, 31st, June 3d and 10th. With cultivator—June 16th and 23d and hand hoed. With cultivator June 29th and July 5th. With hiller July 12th. With hiller July 24th and hand hoed.*

8—Injury by crows, insect pests, etc. *Old beetles ate them a considerable when first came up. The summer hatch of beetles did little damage. Used Paris green on them but once.*

9—Keep record of general appearance of plats during summer. Which plats are most thrifty? Which least thrifty, etc. *July 18th plats on which superphosphate was used and the one of stable manure, tops darkest green. Plats S (stable manure) and N P K (complete fertilizer) a little the most thrifty.*

10—General remarks and questions. *Was well pleased with the experiment. It was both interesting and helpful and was very little extra work or trouble, besides the fertilizer well repaid all the little extra care and grew a fine crop. The experiment showed that the nitrogen used was really detrimental to the potato crop as it caused an extra large growth of vines and LESS TUBERS THAN THE BLANK PLAT.*

We next come to the harvesting of the crop. Bull. 129, p. 146, says:

"In carrying out this part of the work, allowance must be made for the possible growth of the roots of one row into the feeding-ground of the adjoining rows; thus the outside row of one plat may steal food from the next plat, that was not intended for it; hence the directions to exclude the two outside rows of each plat, one on one side and the other on the other side, and not to include the crop of those rows in the harvest measured, are important."

"In measuring the crop, due credit should be given for every part of it that can be utilized in any way; if corn, not only the seed, but the stalks; if wheat, oats, etc., the straw as well as the seed; if potatoes, of course only the tubers."

If each plat contains three rows, then harvest and weigh the middle row. If each plat contains four rows, then harvest and weigh the two inside rows. If each plat contains five rows, then harvest and weigh the three inside rows, and so on.

Bear this important request in mind, namely, that it is necessary to report separately the weight of each crop harvested upon both the limed and unlimed half of each plat.

[Fill out one of the following blank forms as a part of your report of records and observations taken during the summer.]

Size of each plat: length, *16 rods;* width, *½ rod.*

No. of rows grown on each plat. *3.*

No. of rows included in the weighed yield of each plat. *1.*

	PLATS OF CORN.	Limed half of Plats	Unlimed half of Plats
1—Plat **K.**	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
2—Plat **N.**	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
3—Plat **P.**	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
4 Plat **Blank.**	Weight of corn from rows harvested, in pounds. (No fertilizer)	....	....
	Weight of stalks and husks harvested, in pounds	....	....
5—Plat **KN.**	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
6—Plat **KP.**	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
7—Plat **NP.**	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
8—Plat **NPK.**	Weight of corn from rows harvested, in pounds.	....	....
	Weight of stalks and husks harvested, in pounds	....	....
9—Plat **S.**	Weight of corn from rows harvested, in pounds. (Stable manure)	....	....
	Weight of stalks and husks harvested, in pounds	....	....

NOTE.—In case the corn is for fodder and not to be husked, then give the weight of stalks and ears combined.

	PLATS OF POTATOES.	Unlimed Plats
1—Plat K.	Weight of potatoes from rows harvested, in pounds.	*267*
2—Plat N.	Weight of potatoes from rows harvested, in pounds.	*209*
3—Plat P.	Weight of potatoes from rows harvested, in pounds.	*258*
4—Plat Blank.	(No fertilizer) Weight of potatoes from rows harvested, in pounds.	*211*
5—Plat KN.	Weight of potatoes from rows harvested, in pounds.	*240*
6—Plat KP.	Weight of potatoes from rows harvested, in pounds.	*307*
7—Plat NP.	Weight of potatoes from rows harvested, in pounds.	*208*
8—Plat NPK.	Weight of potatoes from rows harvested, in pounds.	*285*
9—Plat S.	(Stable manure) Weight of potatoes from rows harvested, in pounds.	*315*

NOTE.—If some other crop is grown, one of the above blanks can easily be changed and filled out for that particular crop.

At the close of the season and as soon as the results of each plat have been properly recorded, please return this circular to the Chemist of the Experiment Station at Ithaca, N. Y.

G. C. CALDWELL, *Chemist.*
A. L. KNISELY, *Ass't Chemist.*

Name of Experimenter. *Homer H. Jones.*

P. O. *Homer.*

County. *Cortland.*

State. *New York.*

Experiments by Mr. H. H. Jones, Homer, N. Y.—Mr. Jones who made the experiments and sent in this completed report states that each plat was $\frac{1}{2}$ rod wide and 16 rods long, making an area of $\frac{1}{20}$ of an acre. Three rows of potatoes were grown on each plat. In harvesting the crop, the outside rows being discarded according to the directions, the yield of the middle row only of each plat was weighed. This row represented $\frac{1}{60}$ of an acre. The weight of potatoes harvested from the central row of plat K (muriate of potash) was 267 lbs. This yield on $\frac{1}{60}$ of an acre multiplied by 60 gives the yield of pounds per acre, which was 16,020 lbs.; this is equivalent to 267 bushels per acre. It so happens that in this experiment the weight per plat multiplied by 60 gives the yield in pounds per acre and that this product divided by 60 gives the number of bushels per acre. Therefore the number of pounds per plat represents the number of bushels per acre.

Plat (KN)
Potash Nitrogen.
Plat (KP)
Potash Phos. Acid.
Plat (NP)
Nitrogen Phos. Acid.
Plot (NPK)
Nitrogen Phos. Acid. Potash.
Plat (S)
Stable Manure.

60.—*Mr. Jones harvesting and weighing the experimental plats of potatoes.*

What lessons can be drawn from this set of experiments? We will first consider whether it was a profitable investment to use nitrate of soda. (See page 301.) The blank plat gave 211 lbs. of potatoes; the nitrate of soda plat yielded only 209 lbs.; this would indicate that when used alone the nitrate of soda was injurious rather than beneficial. Muriate of potash used alone gave 267 lbs. per plat, an increase of 56 lbs. over no fertilizers, or 56 bushels to the acre. When nitrate of soda was used with muriate of potash the yield was reduced to 240 lbs. per plat. This means that potash plus nitrogen gave 27 bushels less than potash alone. Here again the nitrogen compound was injurious.

Something more of interest and importance may be learned from this series of experiments. For example, it was observed that while the stable manure gave the largest yield, the crop contained the most small potatoes, and the tubers were more scabby than on the other plats. Also where nitrate was used the potatoes were of a poorer quality and more scabby. On the other hand, plats treated with either potash or superphosphate produced very fine, smooth tubers; the plat with a mixture of potash and superphosphate produced as fine a lot of tubers as the Station representative has ever seen.

It is clearly proved by this set of experiments that it would be a waste of money to buy nitrogenous fertilizers for potatoes on this field; but in all probability it might be a good investment to use a moderate amount of potash and superphosphate. It must however not be forgotten that these results, while applicable to this particular field, may or may not be suited to a neighboring farm or even to another part of this same farm; for, on other farms, even if near by, some at least of the conditions of the soil which may affect the crop may and are likely to be different from those of the soil tested by these experiments. The soil of another farm may be quite different, and it may have received quite different treatment in previous years.

Potato experiments by Mr. H. H. Bonnell, Waterloo, N. Y.—Mr. Bonnell has experimented during the past three years. We give here a condensed form of his experiment for 1899. Each plat was $\frac{1}{20}$ of an acre and contained four rows of potatoes. The two central rows were harvested and weighed giving the yield per $\frac{1}{40}$ of an acre for each plat. The figures in the table represent the yield in bushels per acre, calculated from pounds per $\frac{1}{40}$ of an acre.

	Potatoes per acre in bushels calculated from 1-40 of an acre.	
	Large.	Small.
Plat K*	137.7	6.0
" N	129.5	7.3
" P	118.5	8.2
Blank	122.2	6.3
Plat KN	155.2	5.2
" KP	147.0	5.2
" NP	128.0	5.8
" NPK	170.0	5.7
" S	189.0	5.5

* For the meaning of these abbreviations and the rate at which the fertilizers were applied see page 296.

A study of the above table shows that stable manure (S) gave the best results and that a complete fertilizer (NPK) gave the next best. Stable manure having increased the yield of large potatoes 66.8 bu. over the the yield on the blank plat and decreased the yield of small potatoes from 6.3 bu. to 5.5 bu. The complete fertilizer (NPK) increased the yield over the blank plat 47.8 bu. of large potatoes and decreased the yield of small potatoes from 6.3 bu. to 5.7 bu.

Plat (**KP**) *Potash Phos. Acid.*

Plat (**NPK**) *Nitrogen Phos. Acid. Potash.*

Plat (**NP**) *Nitrogen Phos. Acid.*

Plat (**S**) *Stable Manure.*

61.—*Potatoes grown and harvested by Mr. Bonnell.*

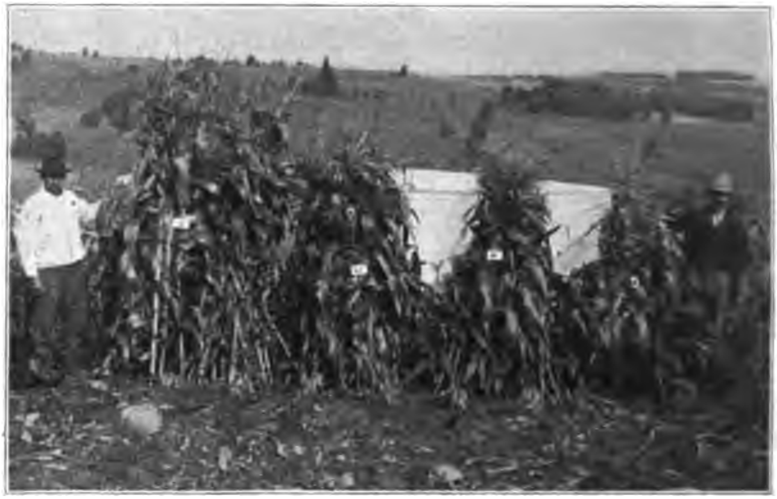
Of the plant-foods used alone, potash gave better results than either nitrogen or superphosphate. Potash, when used with nitrate of soda, gave better results than when used with superphosphate.

The results of these experiments would seem to indicate that a complete fertilizer would give the best results when used on this field, and that the greater portion of it should be potash with only a moderate amount of nitrogen and but little superphosphate.

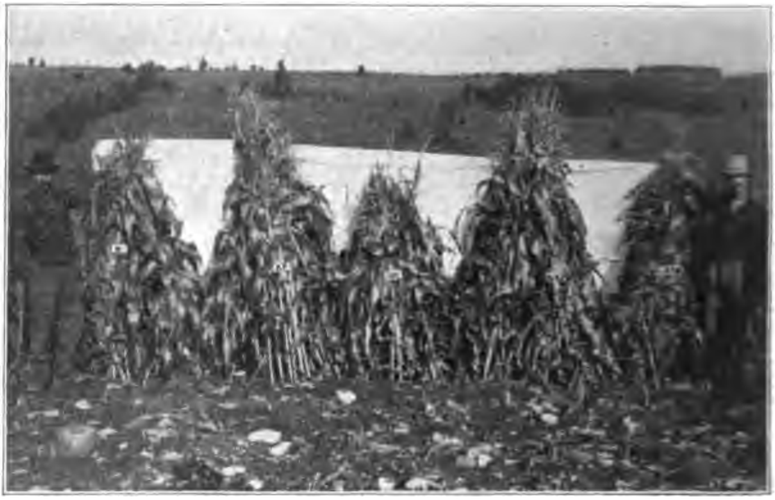
In 1897 Mr. Bonnell experimented with potatoes on another part of the farm; the results indicated that potash gave rather the best results. In 1898 oats were grown on this piece of ground and the superphosphate plats gave the best yields. Again in 1899, two years after the fertilizers had been applied, wheat was grown on it. The plats that had received superphosphate in 1897 still gave the largest crops. These results indicated one of two conditions: either that the cereal plants, oats and wheat, could not find enough phosphoric acid in that soil, unless supplied in the fertilizers; or that the *calcium sulphate* (gypsum or land-plaster), of which all superphosphates are largely composed, gradually made available some of the tightly locked potash that existed in the soil, and that it was this *liberated potash* and not the *phosphoric acid* that gave such marked results the second and third year following the application of the fertilizers.

It was formerly a common practice to use calcium sulphate (plaster) upon land for the purpose of making available some of the tightly locked plant-food especially *potash*.

Experiments of Mr. A. O. Stewart, Mariposa, N. Y.—Mr. Stewart has experimented for the past three years, in 1897 and 1898 on potatoes and in 1899 on corn for the silo. On Sept. 21, '99, one square rod of each plat was cut, shocked and photographed. (See cuts, next page.) Then each shock was weighed and the yield per acre estimated. Also after a week of warm weather the remaining crops on each plat were cut and weighed in order to determine whether the estimated yield per acre would vary much whether based on the yield of one square rod, or of eight square rods. In general, the smaller the area taken for estimating the crop per acre, the greater the probable errors in the calculation. These results are tabulated on page 307.



Plat (**S**) *Stable Manure.* *Plat* (**NP**) *Nitrogen Phos. Acid.* *Plat* (**P**) *Phos. Acid.* *Plat* (**N**) *Nitrogen.*



Plat (**K**) *Potash.* *Plat* (**KP**) *Potash Phos. Acid.* *Plat* (**KN**) *Potash Nitrogen.* *Plat* (**NPK**) *Nitrogen Phos. Acid. Potash.* *Plat* (**Blank**) *No Fertilizer.*

62.—*Mr. Stewart harvesting corn fodder for the silo. Each shock represents the yield from one sq. rod of each plat.*

	Corn silage per acre in tons.		Gain in pounds per acre from Sept. 21 to Sept. 28–99.
	Calculated from one square rod. (Sept. 21st.)	Calculated from eight square rods. (Sept. 28th.)	
Plat K*.........	5.28	5.59	620
" N..........	4.56	4.82	520
" P..........	7.68	8.04	720
Blank...........	4.24	4.51	540
Plat KN........	4.64	4.89	500
" KP	6.88	7.27	780
" NP........	8.80	9.24	880
" NPK	7.84	8.28	880
" S..........	14.48	15.26	1,560

* For the meaning of these abbreviations and the rate at which the fertilizers were applied see page 296.

On studying this table it is plainly seen that available phosphoric acid in the soil was at a minimum since the yield was best on all the plats which received phosphate, whether alone or mixed with one or both of the other plant-foods. It appears further that neither potash nor nitrogen with phosphate added much to the crop over and above the yield with phosphate alone: therefore it would be poor policy to use a complete fertilizer for corn on this field. The experiments of 1897 and 1898 also showed that phosphoric acid was the one plant-food that was deficient in that soil.

On comparing the estimated yields per acre from each cutting, we see that in every case there was a decided increase in the total crop during the last week of growth and that these increases per ton were quite uniform. This shows that the estimated yields per acre when calculated either from one square rod or from eight square rods are very nearly alike and that correct results can be obtained by measuring the crop of a part only of each plat.

The value of stable manure as a fertilizer is very distinctly shown in the results of this series of experiments, the increase over the yield on the blank plat being more than three times the increase given by any other fertilizer. Although the quantity of the manure applied contained less available nitrogen compounds, potash and phosphate than was contained in the commercial fertilizers used, it was far ahead of the other fertilizers. This result may be due in part to the useful bacteria possibly in the manure, or to the effect of the manure on the physical qualities of the soil, such as its texture, its temperature, etc.

Many other illustrations might be given of the value to the farmer of this kind of experimentation, but lack of space forbids.

Injury caused by Fertilizers.—As already stated in this bulletin, not all the experiments were entirely successful. In some cases the plats were too small, in others not enough care was taken in mixing the fertilizers thoroughly with the soil; the result was either a partial injury to the crop, or killing it completely. Such injurious effects were especially noticeable with the muriate of potash and nitrate of soda. The superphosphate did not seem to cause any damage even when applied very close to the plant or in large quantities, even at the rate of two tons per acre, as in some cases by mistake. Superphosphate may therefore be used very carelessly without doing any harm, while great care must be exercised in the application of nitrate of soda or muriate of potash.

Does it pay to use commercial fertilizers?—This question is frequently asked by farmers, but it is a question that can be answered only by the questioners themselves. They, only, know what the purchased fertilizers cost them ; they only can know or they ought to know what increase of crop is yielded by the fertilizers applied, and how much money they have received for such increase. As a rule, they know only what they have paid for the fertilizers, and how many bushels or tons of their crops they have harvested; but they do not know how many bushels or tons are to be credited to the fertilizers, for they do not know how much the soil will yield without any fertilizer, or with stable manure. Neither do they know what the stable manure has cost them. Furthermore, since as a rule they use complete fertilizers, containing all three of the plant-foods, nitrogen compounds, potash and phosphate, therefore they do not know whether any increase in crop is due to the action of all three of the plant-foods, or to two of them, or to one only. In the case of several of the series of experiments that have been carried out under the supervision of this Station, it has been conclusively shown that phosphate was the only plant-food that was useful, and that all the money paid for the other two was wasted.

Such being the results of a number of the experiments with fertilizers, it would seem that a wise and prudent farmer would attempt to keep a sort of a bank account with every field on his farm that is under cultivation. To accomplish this he would charge to each field the cost of the fertilizer applied to it, if he uses commercial fertilizers; after the harvest he would credit every field with the market value of its produce. It would cost him but little time and labor to measure three plats, say of a tenth of an acre, in each field to be treated with commercial fertilizers, one plat being left unfertilized; multiplying the yield of each of these plats by ten would give the yield per acre. He has then all the data that are necessary in order that he may learn by a simple calculation whether the increase of the crop has more than paid for the cost of the fertilizer used.

The farmer may say that he cannot spare the time for carrying out this plan; or he may say that he does not want to lose the increase of crop that the fertilizer would give on the one unmanured plat. But this loss on a tenth of an acre only, would be very small and it would be of much more importance to him to know whether he gains or loses by the application of fertilizers. Better still would it be if he could carry on a set of experiments with the three important plant-foods in a complete fertilizer, in the manner described in the preceding pages. He might then learn that only one of the three foods, say, for example, the phosphoric acid in a plain superphosphate, or potash, or some combination of two of the three foods is all that the field experimented upon requires, and that money spent for any other food is simply thrown away.

Frequently during the summer the representative of the Station was asked by the farmers if it would pay to use such large quantities of fertilizers as were sent out by the Station and if smaller quantities would not do just as well. The answer was that in these experiments the cost of the fertilizers was not taken into consideration, the main object being to find out whether the use of any one or more of the plant-foods would give profitable yields over and above the yield without any fertilizer. For such a purpose it is better to use large applications rather than small ones in order to make the results of the experiment more marked.

With the cultivated fields of this State in their present condition, with their present amounts of humus and with their present texture, it will not pay, as a general thing, to use large applications of fertilizers, because moderate amounts are usually sufficient to make the available plant-food conditions as good or better than other essential conditions of the soil. Just as soon as plant-food conditions are better than other essential conditions, the plant will not be able to get the benefit of this extra food, and more or less may be wasted.

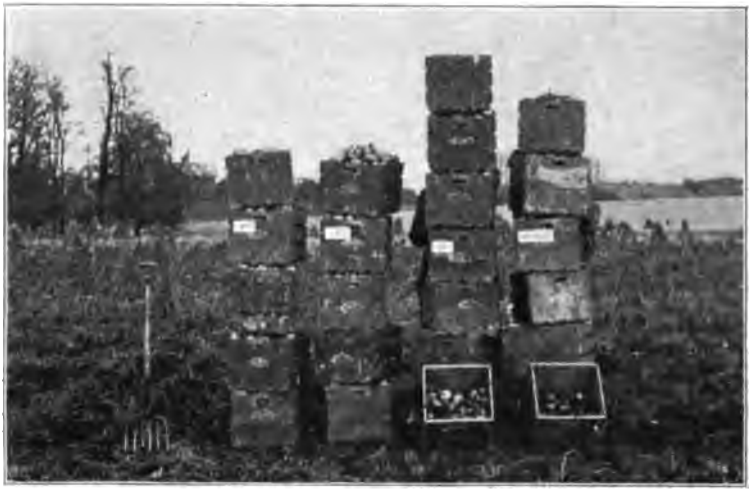
63.—*Mr. Mabee, of Spencer, N. Y., harvesting and weighing experimental plats of potatoes.*

Interest in the experimental work and its value.—In most cases the farmers were very much interested and painstaking with the work. Oftentimes the experimenters said that the work was being watched by neighbors, for they wanted to "see whether there is anything in it or not."

Mr. Wills C. Hatch, of Skaneateles, N. Y., wrote as follows: "Below you will find the results of my third experiment with fertilizers on potatoes under your supervision. Each year's experiments gave practically the same results, proving to me beyond doubt what I had before believed, that the soil on my farm did not need the addition of either potash or nitrogen, or in other words it would not pay me to use them. I am now using plain phosphate alone on all my crops and am getting better results than with the mixed goods. This will save me from fifty to one hundred dollars a year in the cost of purchased fertilizers, and with better results.

The results of my experiments have been given in the Grange and club meetings and also published in the papers. Whether this had anything to do with the case or not I don't know, but I do know that of about forty tons used by our Grange this season only one ton used was other than plain phosphoric acid goods."

Mr. A. O. Stewart, of Mariposa, N. Y., wrote as follows: "In making my report I wish to assure you that we have been greatly benefited by the experimental work in many ways. We have learned that the better preparation of the soil and good cultivation are the prime requisites of a good crop.



Plat (N) *Plat* (K) *Plat* (P) *Plat* (**Blank**)
Nitrogen. Potash. Phos. Acid. No fertilizer.

64.—*Potatoes harvested from four of the experimental plats of Mr. Hatch.*

In making these experiments the past three years we have, with the kindly help and suggestions of the Experiment Station, been able to determine what our soil requires, and now in buying fertilizers we buy only what our soil most needs, thus reducing the cost of the fertilizer bought nearly 50 per cent. Several of our neighbors have been interested in our experimental work and they requested me this last spring to purchase for them a fertilizer containing only phosphoric acid. They claim that it gave them good results on all crops, equally as good as a complete fertilizer costing nearly twice as much, and this in alternate pieces and with the same cultivation."

From a letter of Mr. Chas. Vanderbilt, Alloway, N. Y., we quote, "I am very glad that I undertook the fertilizer experiment work, as it has helped me to know what our land needs, and my neighbors are just beginning to think that one can tell what one needs by carrying on the experimental work. I think that acid phosphate, or superphosphate, will show up better than anything else on our clay land as the work shows so far; and some of our neighbors are going to try acid phosphate as an experiment on their wheat this fall through me. * * * * As I have got started in the experimental work I shall never stop it. I shall keep on experimenting."

Farmers who have experimented.—The following is a list of the farmers to whom sets of fertilizers have been sent. Some have received them but once, others twice, and still others three times. The column headed "Years of Experimentation" indicates the number of years that each farmer has experimented and how many successive sets of fertilizers have been sent to him.

Name of experimenter.	Post office.	County.	Years of experimentation.
Ackley, Denver	Gowanda	Cattaraugus	1
Adcook, George	Fayetteville	Onondaga	1
Akeley, Ward B	Holley	Orleans	2
Akin, James L	Fluvanna	Chautauqua	1
Albright, John H	Ontario	Wayne	1
Allen, John J	Depauville	Jefferson	1
Allendorph, D	Sliters	Renssalaer	2
Almy, W. C	Dundee	Yates	2
Anderson John	Oriskany Falls	Oneida	3
Anderson, R. E	North Wilna	Jefferson	1
Andrews, F. M.	Pompey	Onondaga	1
Averell, Warren	Caledonia	Livingston	1
Backus, J. H	Little Genesee	Allegany	1
Bagg, S. F	Watertown	Jefferson	1
Bailey, A. M	Townsend	Schuyler	2
Baker, N. A	Fishers	Ontario	3
Baldridge, C. J	Kendaia	Seneca	1
Banglar, Frank	East Bloomfield	Ontario	1
Banta, C. J	Conklin	Broome	1
Barney, Frank D	Westfield	Chautauqua	1
Barris, McClellan	Silver Creek	Chautauqua	1
Barrows, George A	Groton	Tompkins	2
Bassett, B. A	Afton	Chenango	1
Bates, C. A	Ellington	Chautauqua	1
Beadle, Geo	Brockport	Monroe	1
Beardsley, F. E	Coventry	Chenango	1
Belknap, J. J	Campville	Tioga	1
Benjamin, Chase	Haskinville	Steuben	2

Name of experimenter.	Post office.	County.	Years of experimentation.
Bennett, Bert	Howard	Steuben	1
Bingham, G. W	Summer Hill	Cayuga	2
Bingham, Henry M	Albion	Orleans	1
Bird, Albert A	Otto	Cattaraugus	2
Birge, E Pratt	Chatham	Columbia	1
Black, J. E	Ithaca	Tompkins	1
Bleaker, Joseph	Mumford	Livingston	1
Bliss, Geo. A	Groton City	Tompkins	3
Blood, Elmer E	West Potsdam	St. Lawrence	1
Bonnell, H. H	Waterloo	Seneca	3
Boynton, L. R	Lakeside	Wayne	1
Briggs, G. D	Lima	Livingston	1
Brigham, R. W	Perry	Wyoming	1
Brill, Thomas	Poughquag	Dutchess	1
Brodie, Geo	Churchville	Monroe	1
Bronson, Geo. H	Vernon Centre	Oneida	1
Brown, Cassius S	*West Bethany	Genesee	2
Brown, P. E	Cicero Centre	Onondaga	1
Buckland, W. F	Lysander	Onondaga	2
Bulkeley, R. P	Coventryville	Chenango	1
Burke, T. Tracy	Afton	Chenango	1
Burnham, Wm. H	Groton	Tompkins	1
Burritt, F. M	Parma Centre	Orleans	1
Burritt, W. B	Hilton	Orleans	1
Campbell, John H	Caledonia	Livingston	1
Cardner, G. R	Tully	Onondaga	1
Carlile, David	Eureka	Sullivan	1
Cary, H. L	Lockwood	Tioga	1
Catchpole, E. W	North Rose	Wayne	1
Cavanaugh, G. W	Watertown	Jefferson	1
Chaffee, L. R	Natural Bridge	Jefferson	1
Chamberlain, Ed	Barnes' Corners	Jefferson	1
Chapman, C. E	Peruville	Tompkins	1
Child, Lewis E	Philadelphia	Jefferson	1
Christy, W. T	Silver Creek	Chautauqua	1
Clark, C. J	LaFayette	Onondaga	1
Clark, C. W	Skaneateles	Onondaga	1
Clark, Ernest A	East Onondaga	Onondaga	1
Clothier, F. B	Silver Creek	Chautauqua	1
Clothier, H. B	Silver Creek	Chautauqua	2
Cockburn, Frank M	Silver Creek	Chautauqua	1
Cockburn, J. E	Silver Creek	Chautauqua	1
Cole, A. P	Howard	Steuben	2
Conklin, Geo. E	Chappaqua	Westchester	1
Cooley, G. W	Verona	Oneida	1
Corbett, M. J	Corbettsville	Broome	1
Cowles, James S	Otisco	Onondaga	1
Curtis, C. H	Waterville	Oneida	2
Curtis, Herbert S	Ridgeland	Monroe	1
Davis, C. E	Heath	Ulster	1
Day, H. N	Canandaigua	Ontario	1

Name of experimenter.	Post office.	County.	Years of experimentation.
Denison, F. E.	Westfield	Chautauqua	1
Drummond, Wm.	Perry City	Schuyler	1
Dudley, Henry C	Bath	Steuben	1
Dunn, Geo. W.	Forest Lawn	Monroe	2
Dunton, H. V.	Camden	Oneida	1
Durham, Wm. C.	Mount Kisco	Westchester	1
Dye, Ernest B.	Villenovia	Cattaraugus	1
Eastman, John M	Woodville	Jefferson	1
Elmendorf, W. E	Strait's Corners	Tioga	1
Emmons, Roy D.	Pulaski	Oswego	1
English, Andrew	Van Etten	Chemung	1
Field, Harry T.	Oneida	Oneida	1
Fitzgerald, Wm.	Alpine	Schuyler	1
Fosmire, Frank L	Freeport	Queens	1
Fredenburg, Lewis E	Afton	Chenango	2
Fullagar, Howard.	Penn Yan	Yates	1
Fuller, James S	Poland	Herkimer	1
Fullington, M. C.	Warsaw	Wyoming	1
Garlock, William	Marshville	Montgomery	1
Garrett, J. D.	North Syracuse	Onondaga	2
Geer, Harvey L	Forestville	Chautauqua	1
Goodwin, Geo. A	Auburn	Cayuga	1
Greene, Chas. S.	East German	Chenango	1
Griffin, Maurice N	Rutland	Jefferson	1
Grinnell, W. M	Broadalbin	Fulton	1
Guilford, C. R	Cuba	Allegany	1
Hall, G. A	Red Creek	Monroe	1
Harrison, L. E	North Winfield	Herkimer	1
Hartley, S. F	Gouverneur	St. Lawrence	1
Hatch, Wills C	Skaneateles	Onondaga	3
Hawkins, Noel	Gowanda	Cattaraugus	1
Heap, Henry	Hamilton	Madison	1
Heath, Adelbert L	DeRuyter	Madison	1
Hendrick, James	Slingerlands	Albany	1
Hess, Chas. F	Great Valley	Cattaraugus	1
Heyward, William	Stafford	Genesee	1
Hills, J. Bert	DeRuyter	Madison	1
Hoffman, E. M	Appleton	Niagara	1
Holmes, Frank	Marietta	Onondaga	1
Howard, F. W	Fredonia	Chautauqua	2
Howe, W. D	Fayette	Seneca	1
Hoyt, Frank D	Cicero	Onondaga	1
Hulbert, Lorenzo	Dansville	Livingston	3
Hulett, Henry	French Creek	Chautauqua	3
Hungerford, Nye	Ithaca	Tompkins	1
Ingalls, Chas. W	Watkins	Schuyler	1
Irwin, Wm A	Stone Mills	Jefferson	2
Jackman, Geo. W	Livonia Station	Livingston	2
Jacks, Corwin	Batavia	Genesee	2
James, V. L	Cooperstown	Otsego	2
Jeffords, Harry A	Upper Lisle	Broome	1

Name of experimenter.	Post office.	County.	Years of experimentation.
Jenkins, E. E	Wolcott	Wayne	1
Jerry, E. J	Risingville	Steuben	1
Johnson, Truman I	North Ridgeway	Orleans	2
Jones, David W	Nelson	Madison	1
Jones, H. H	Homer	Cortland	1
Jones, Thomas W	Watervale	Onondaga	2
Kales, Dr. John W	Franklinville	Cattaraugus	3
Keener, C. L	Potsdam	St. Lawrence	1
Knapp, A. A	Preble	Onondaga	1
Knapp, C. E	Little York	Cortland	1
Knowles, W. A	Germantown	Columbia	1
Koon, Archie M	Auburn	Cayuga	1
Kyes, Caleb	Natural Bridge	Jefferson	1
LaFrenay, Clark C	Hammond	St. Lawrence	1
Lane, Lloyd W	Lyons	Wayne	1
Langdon, E. R	Hermitage	Wyoming	1
Lanphear, Perry	Black River	Jefferson	2
Lewis, R. N	Red Hook	Dutchess	2
Lindsley, B. M	Monticello	Sullivan	2
Lockley, Jesse B	Pultneyville	Wayne	1
Lombard, Louis	Jonesville	Saratoga	1
Long, John D	Williamsville	Erie	1
Loomis, Eugene W	Wilson	Niagara	1
Mabee, C. T	West Candor	Tioga	3
Mabee, E. J	West Candor	Tioga	1
Mapes, Arlington	Rushville	Yates	1
McBirney, S. J	Smithville Flats	Chenango	2
McDonough, John	East Bloomfield	Ontario	1
McMurray, A. H	Walworth	Wayne	1
McNair, A. D	Dansville	Livingston	1
McNair, H. R	Dansville	Livingston	3
Mead, U. W	Forestville	Chautauqua	2
Mead, W. B	Portland	Chautauqua	1
Medbury, C. B	Rockdale	Chenango	2
Metz, John U	Williamsville	Erie	2
Miller, D. M	South Otselic	Chenango	1
Miller, Gage M	Chili Centre	Monroe	1
Moore, D. M	Hooper	Broome	1
Morse, Frank E	Dalton	Livingston	2
Munson, J. O	East Lansing	Tompkins	2
Nash, D. D	Ellisburg	Jefferson	1
Nicholas, T. B	Center	Herkimer	3
North, Geo. R	Copenhagen	Lewis	1
Oaks, Jerome	Ketchumville	Tioga	2
Oaks, W. A	Oaks Corners	Ontario	1
Osborne, Chas. L	Rose	Wayne	2
Ovenshire, T. C	Bath	Steuben	1
Palmer, J. D	Montour Falls	Schuyler	3
Parker, Julius J	Fredonia	Chautauqua	2
Pattat, John	Little France	Oswego	1
Pease, Ira	Oswego	Oswego	1

Name of experimenter.	Post office.	County.	Years of experimentation.
Peo, James A	River View	Jefferson	1
Percy, Martin	Sodus	Wayne	1
Perkins, D. Center	Castile	Wyoming	2
Petrie, J. F	Plessis	Jefferson	2
Pierce, Dr. B	Coopers Plains	Steuben	1
Platt, Clarence J	Hamburg	Erie	1
Poole, J	Center Village	Broome	1
Price, Geo. H	Newark	Wayne	2
Putnam, Wm. R	Wayville	Saratoga	1
Quereau, C. N	Baldwinsville	Onondaga	1
Randolph, Alva F	Alfred	Allegany	3
Render, Geo. H	Antwerp	Jefferson	1
Rice, Ammon	Wolcott	Wayne	1
Rice Frank D	Homer	Cortland	1
Richardson, B. F	Rome	Oneida	1
Robb, C. F	Webster	Monroe	1
Roe, A. LaVerne	Plymouth	Chenango	1
Rogers, Geo. A	Brookfield	Madison	2
Rumsey, Burr	Ithaca	Tompkins	1
Rutherford, Thomas	Hammond	St Lawrence.	2
Salisbury, J. L	Phelps	Ontario	2
Sanders, Chas P	Schenectady	Schenectady.	2
Schoonmaker & Son	CedarHill	Albany	1
Sears, Geo. L	French Creek	Chautauqua	2
Seeber, D. V	Perch River	Jefferson	2
Seeley, R. F	Waterloo	Seneca	1
Selby, A. F	Pultneyville	Wayne	1
Seymour. J. L	Turin	Lewis	1
Shedd, Maurice H	Lowell	Oneida	1
Siddon, Chas	Syracuse	Onondaga	2
Simpson, Frank	Jasper	Steuben	1
Smith, Carlos F	Charlton	Saratoga	1
Smith, Clarence	Forestville	Chautauqua	1
Smith, W C	Candor	Tioga	1
Snow, C. L	Forestville	Chautauqua	1
Southard, D. W	Gilboa	Schoharie	1
Stanton, Chas. E	East Venice	Cayuga	2
Staplin, Jr., Geo	Mannsville	Jefferson	2
*Starr, Jesse K	Fredonia	Chautauqua	1
Steele, H. J	Elba	Genesee	1
Stephenson, Geo	Ballston Spa	Saratoga	1
Sterling, E. S	Eagle Harbor	Orleans	2
Stewart, A. O	Mariposa	Chenango	3
St. John, J. Henry	Cohocton	Steuben	1
St. John, C. L	Canajoharie	Montgomery.	1
St. John, Lewis S	Canajoharie	Montgomery.	1
Stone. C. A	Pine City	Chemung	1
Storms, E. G	St. Johnsville	Montgomery.	1
Strickland, W. J	Albion	Orleans	1
Suydam, Nelson S	Binghamton	Broome	2

* Mr. Starr furnished his own fertilizers.

Name of experimenter.	Post office.	County.	Years of experimentation.
Taber, H. B	Wells Bridge	Otsego	1
Thomson, F. H	Holland Patent	Oneida	1
Torrence, Clay	Gowanda	Cattaraugus	2
Tubbs, Martin W	Portville	Cattaraugus	1
Turney, John R	Lairdsville	Oneida	1
Tuttle, C. H.	Smyrna	Chenango	2
Twitchell, A. B	Pulaski	Oswego	1
Tyrrell, Geo. F	Wolcott	Wayne	1
Tyrrell, J. S	Wolcott	Wayne	1
Ulrick, H. W	Owego	Tioga	1
Vanderbilt, Chas	Alloway	Wayne	2
Van Buskirk, S. B	Purdy Creek	Steuben	2
Van Santford, A. P	Tribes Hill	Montgomery	1
Vary & Son, Nathan C	Ava	Oneida	2
Wager, Ben. M	Catharine	Schuyler	3
Walker, A. J	Portland	Chautauqua	1
Walker, Robt. F	Rome	Oneida	1
Wallace, A. P	Morristown	St. Lawrence	1
Wallis, Edward G	Apulia	Onondaga	1
Warford, C. O	Newburgh	Orange	2
Waterbury, C. B	Whitelaw	Madison	3
Watson, Maurice J	Center Village	Broome	1
Weeks, W. R	Scottsville	Monroe	1
Wells, Geo. S	Knoxboro	Oneida	3
Wheeler, Oscar	Hornellsville	Steuben	1
Wheelock, E. W	Mexico	Oswego	2
Whitcomb, C. H	West Somerset	Niagara	2
*Wilbur, O. B	North Easton	Washington	1
Wilcox, B. F	East Glenville	Schenectady	1
Wilkinson, Ed. C	Penn Yan	Yates	1
Williams, Frank	Catatonk	Tioga	2
Willing, E. L	Sherman	Chautauqua	2
Willson, John R	Shortsville	Ontario	1
Winters, Harry B	Smithboro	Tioga	2
Wood, Geo. W	Northfield	Delaware	1
Woodford, L. L	Berwyn	Onondaga	1
Worden, Palmer	Fayetteville	Onondaga	1
Yates, Martha G	Slaterville Springs	Tompkins	3
York, A. L	North Brookfield	Madison	1
Young, Frank E	East Venice	Cayuga	1

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* Mr. Wilbur furnished his own fertilizers.

General results of the field experiments.—A study of all the experiments for three years recorded shows that of the three plant-foods when used alone, nitrogen gave the largest increased yield in 26 experiments, phosphoric acid in 58 experiments and potash in 36 experiments. This would seem to indicate that when one plant-food is used alone, phosphoric acid will in most cases give the best results. When a mixture of two plant-foods was applied, nitrogen and potash gave best results in 24 experiments, phosphoric acid and potash in 48 experiments, and nitrogen and phosphoric acid in 52 experiments. A comparison of a complete fertilizer and stable manure shows in 38 experiments the complete fertilizer gave better results, while in 54 cases stable manure produced the larger crops. These good results accompanying the use of stable manure may not be due so much to the plant-food it contains as to an improvement in the physical conditions of the soil.

In only 40 cases out of a total of 126 recorded, did the complete fertilizer, a mixture of nitrate of soda, phosphate and muriate of potash, give better results than fertilizers containing one or two of the plant-foods.

These results tend to show that more often it is some especially prepared rather than a complete fertilizer that a soil requires, and that when a farmer uses commercial fertilizers he is often not following the wisest policy; he is simply "going it blind" and possibly throwing away money.

A. L. KNISELY.

NOTE.—Farmers wishing to co-operate with the Experiment Station in conducting field experiments with fertilizers should make application soon to G. C. CALDWELL, Chemist. Then if the Station is permitted to continue this experimental work, much valuable time lost in correspondence will have been saved.

Bulletin 180. [redacted] **March, 1900.**

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

BOTANICAL DIVISION.

THE PREVENTION OF PEACH LEAF-CURL.

By W. A. MURRILL.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1900.

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The regular bulletins of the Station are sent free to all who request them

* Absent on leave.

CORNELL UNIVERSITY, ITHACA, N. Y., March 1, 1900.
HONORABLE COMMISSIONER OF AGRICULTURE,
ALBANY, N. Y.

Sir:—One of the most trying experiences of the orchardist and also one of the most frequent, is to see his trees bloom but not set fruit. Various investigations of such difficulties have been made and published, but much more needs to be done. In order to understand the subject, particularly in its relations to practical orcharding, an investigation was set on foot by Professor Bailey. This investigation has been continued three years under his direction and supervision, and the summary results are published in this bulletin, which is submitted for publication under Chapter 430 of the Laws of 1899.

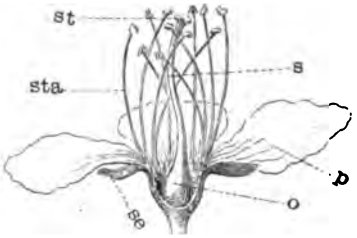
The study of pollination in orchards is made necessary by the rise of commercial fruit-growing. When fruit is grown only for home use, or in small areas for a local market, there is not likely to be serious loss from imperfect pollination; but in large commercial orchards, any general unfruitfulness from this source is quickly noticed. The commercial orchard seems destined to be the most important single factor in American horticulture, and with its growth comes a corresponding increase in the liability of loss from imperfect pollination. This bulletin will find its greatest usefulness, therefore, in the hands of the commercial fruit-grower. Aside from extended investigations in this State, experiences have been secured from all parts of the country.

This bulletin is divided into two parts:

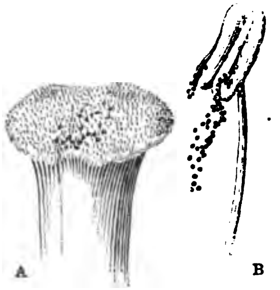
I. Incidental or occasional causes for loss of fruit.

II. Self-sterility, which is the main part of the work.

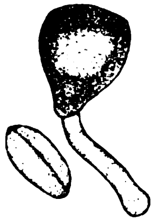
Respectfully submitted,
I. P. ROBERTS, Director.



65.—*The structure of a plum blossom. se. sepals; p. petals; sta. stamens; o. ovary; s. style; st. stigma. The pistil is comprised of the ovary, style and stigma. It contains the female part. The stamens are tipped with anthers in which the pollen, or male part, is borne. The ovary, o, ripens into the fruit.*



66.—*B, pollen escaping from anther. A, pollen germinating on the stigma. Enlarged. The transfer of pollen to the stigma is called pollination.*



67.—*Pollen grain germinating. Greatly magnified.*

65-67.—*Details of a fruit blossom.*

68.—*At 7 a. m.*

69.—*At 10 a. m*

70.—*At 3 p. m.*

71.—*At 8 a. m. the next morning.*

68-71.—*The opening of a flower of Kieffer pear. The flowers of pears and apples have five styles and stigmas. All natural size.*
(Courtesy of *American Gardening*.)

POLLINATION IN ORCHARDS.

I. VARIOUS REASONS WHY FLOWERS DO NOT SET.

All observing fruit-growers have seen trees which blossom full but do not set a fair amount of fruit; many have found their orchards unprofitable for this reason. It is a practical point to know the causes of this loss and the best way to prevent it.

Not all the flowers can set fruit.

In the first place, but a small percentage of the blossoms set fruit anyway, even in the most favorable seasons and with the most productive varieties. In blossoming time a Japanese plum tree is a mass of white, carrying scores of flowers on a single branch; yet scarcely a dozen fruits may set on that twig, and some of those must be removed or the tree will overbear. In the pollination work at Ithaca in 1899, 4,725 untouched blossoms, including apples, pears, plums and apricots, set but 617 fruits. The blossoms counted were those on the tree at large and were used for comparison with the hand crosses. This is about one fruit for every eight blossoms; yet most of the trees set what would be called a good crop. All of these blossoms were apparently uninjured by the winter, and the weather during the blossoming season was very favorable for the setting of fruit.

This normal failure in the setting of fruit blossoms may be due to a number of causes; as poorly nourished fruit-buds, lack of pollination, or winter injury to the pistils which cannot be seen with the eye alone. It is usually a distinct advantage to the fruit-grower, as it saves thinning. If all plum blossoms set fruit, the expense of thinning would be multiplied many times. Only when the failure of fruit blossoms to set becomes general, does the fruit-grower feel the loss and call for an explanation.

This wholesale failure in the setting of fruit is often called self-sterility. Properly speaking, a self-sterile tree is one which is self-unfruitful: it must have other varietes near it in order to bear well. But it appears that self-sterility in orchard fruits is often confused with the unfruitfulness resulting from other causes.

It would therefore be well to clear away this confusion at the outset, in order that the discussion of self-sterility may be better understood. The influences which sometimes make trees unfruitful, which are often confused with the unfruitfulness resulting from self-sterility, are (1) heavy wood growth, (2) the attack of fungi on the blossoms, (3) frosts, (4) unfavorable weather during the blooming season. It should also be said that a tree is not self-sterile when it does not blossom. This bulletin does not attempt to tell why trees do not bloom, except that it is generally due to poor management. The only thing which concerns us now is, why trees which blossom full do not set a reasonable amount of fruit.

Blossoms may drop because of heavy wood growth.

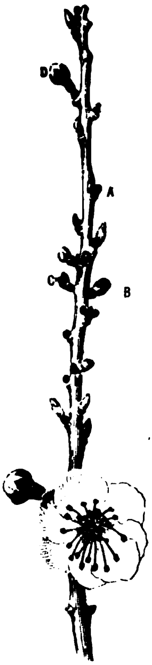
Young trees generally set little or no fruit the first few years, when they are growing fast, although they may blossom full. With most varieties this early dropping of the blossoms occurs only two or three seasons, but Northern Spy and a few other varieties of apples are often unfruitful ten to thirteen years from this cause. Older trees may show the same results if stimulated too highly with nitrogenous fertilizers. The logical remedy is to check this excessive growth of wood by witholding nitrogen or by putting the orchard into sod for a few years.

The direct cause of this unfruitfulness is not known. The stamens and pistils are usually well developed and pollen may be produced in abundance. Since young trees drop their blossoms as badly in a mixed orchard where other pollen is available, as when alone, the trouble probably lies more with the pistils than with the pollen.

Up to this limit of excessive growth, there is a fairly constant relation between the vigor of a tree and its productiveness. Lack of vigor causes much more unfruitfulness than excessive vigor. If a tree is unhealthy or dying because of poor nourishment, few of its blossoms are strong enough to set fruit. The same results may follow if the tree is exhausted by over-bearing.

Blossoms may be killed by fungi.

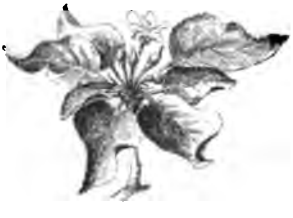
If the weather is warm and wet in early spring, conditions are favorable for the growth of fungi and it sometimes happens that fruit blossoms are "blasted" by the early growth of these parasites. The common brown-rot fungus often kills peach blossoms and may seriously decrease the setting of fruit. It is probable that this fungus sometimes attacks plum and cherry blossoms also. Apple and pear scab may kill the blossoms, but more often it kills the young fruits soon after they are set. Wherever spraying is practiced faithfully, the killing of fruit blossoms by fungi need not occur, especially if one thorough application is made to the trees before the buds open. The killing of pear blossoms by blight, however, cannot be prevented by spraying. The blossoms on Kieffer and LeConte trees are especially liable to be destroyed by the growth of blight microbes, which are carried from flower to flower. The only way to prevent this loss is to have no blighted trees in or near the orchard.



72.—*Winter-injured fruit buds of Royal apricot.*

Winter and spring frost may injure the blossoms.

The unfruitfulness arising from winter or spring frost injury is sometimes confused with self-sterility. Various forms of winter injury to fruit buds are shown in Figs. 72–77. At A in Fig. 72 is a fruit bud which has been completely winter-killed and has made no growth whatever. B and C are buds which will never be able to open; while D is a very weak blossom which cannot set fruit. The single open flower on this branch is the only one which can possibly set fruit. A winter-injured cluster of Bietigheimer blossoms is seen in Fig. 73, with a section of one bud in Fig. 74 to show the shriveled stamens and pistils. The leaves in this cluster came through all right, but the flowers were injured. The single flower which has expanded is too small and weak to develop into fruit. These winter-injured clusters were



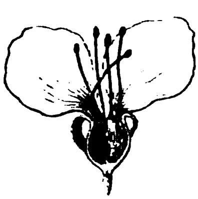
73.—*Winter-injured fruit buds of Bietigheimer apple.*

common on all varieties of pears, particularly Angouleme and Manning Elizabeth, and on some varieties of apples, in the spring of 1899.

Two forms of winter or spring frost injury to the pistils are seen in Fig. 75 and 76, with a normal blossom for comparison in Fig. 77. A common form of injury is that in Fig. 75, in which the pistil is blackened and stunted, having made no perceptible growth during the opening of the flower. These pistils always drop from the tree soon after the petals have fallen. Another and not less common form of injury is that in Fig. 76, in which the pistil has made a partial growth but has no well developed ovary. Unless a careful examination is made, blossoms like this would not be considered as winter-injured. Of fifty which were tagged, none gave fruit, although several fruits grew to the size of peas. The killing of the pistils is the most common form of winter injury to fruit buds. Some of the native and Japanese plums had as high as 80 per cent of defective pistils last spring, but with their enormous amount of bloom this did not materially decrease the crop of fruit which the trees were able to carry. The Japanese plums bloom so early that their blossoms are liable to be injured by frost in the middle states and south.

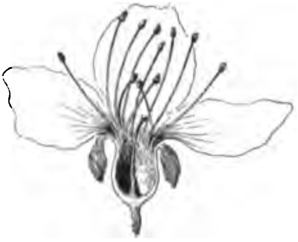
74.—*Section of one bud in Fig. 73.*

It is thus seen that the injury to fruit blossoms from cold is of all degrees. During the opening of a normal flower, the pistil grows. It is often taken for granted that if this growth occurs the pistil is uninjured; but it may be that even though a pistil reaches its full size, it may yet be so injured that it cannot develop into fruit. In 1899 about ten per cent of the blossom buds of a Royal apricot opened fully, like the one in Fig. 72. All of these blossoms appeared to be perfect, with long pistils, plump ovaries and well developed stamens. Yet hardly a dozen fruits set on the whole tree, although the weather during the blooming season was ideal, bees were numerous, and some of the



75.—*Catherine apricot; injured pistil.*

flowers were even crossed by hand with the pollen of other varieties. Since the variety had already shown itself so susceptible to winter injury, it is probable that this wholesale failure was due to the weakened vitality of the pistils, which could not be seen with the eye alone.

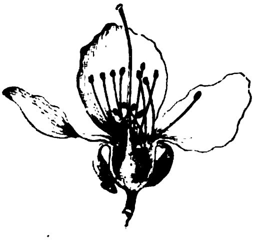


76.—*Catherine; injured pistil.*

Some of the imperfect development of flowers which we attribute to winter injury may be caused by unfavorable conditions during the previous season, when the buds were being formed; yet it seems likely that winter injury to pistils is more common and more serious than appears at first sight. These remarks on winter injury are introduced simply to emphasize the fact that all blossoms which do not set fruit are not self-sterile; and also to promote a more careful discrimination between the various causes which decrease the setting of fruit.

Rain may injure fruit blossoms.

The unfruitfulness which often follows a rain during the blooming season is sometimes confused with self-sterility. A careful fruit-grower watches the weather anxiously when his trees are in blossom, for he knows this is the most critical period in the growth of the crop. Injury to fruit blossoms from rain is common wherever fruit is grown, but is particularly serious along the Pacific coast and near the shores of the Great Lakes. It has been estimated that more fruit is lost in California from cold rains during blooming time than from all other causes combined. Like winter injury to fruit buds, there is no way of preventing this loss except to secure a more favorable location, since it is not in man's power to prevent rain, however much he may be able to induce it by bombarding the sky. Nevertheless, it is interesting to know in what way rain decreases the setting of fruit.



77.—*Catherine; normal flower.*

If a rain comes while the trees are in full bloom the pollen is washed from those anthers which have already opened, and is thus prevented from reaching the stigma. Should the rain be a short one, no serious harm need result from this loss of pollen, for the unopened anthers will burst and pollination will begin again soon after the sun comes out. The washing away of pollen has very little influence in decreasing the setting of fruit, particularly when the rain is short. There will generally be enough pollen to supply the pistils before or after the rain.

The poor setting of fruit which often follows a long rain and sometimes a shower is due more to a loss of vitality in the pollen or to some mechanical injury to the pistils; also, in large measure, to the fact that bees and other insects which promote the beneficial cross-pollination between varieties are absent. If the rain lasts for several days, the pollen may lose its vitality. After a week of rainy weather at Ithaca in the spring of 1898, nearly all the pollen of the apricots then in bloom was disorganized and stuck together, so that it could not possibly grow and fertilize the pistils. Some of this pollen is shown in Fig. 78. It is also natural to suppose that a hard rain may wash off, dilute, or otherwise injure the juices of the stigma so that the pollen cannot germinate after it falls upon the stigma. Perhaps a long "spell" of wet weather may even kill the pistils after they have been fertilized.

78.—*Pollen injured by rain. Much magnified. Compare Fig. 80.*

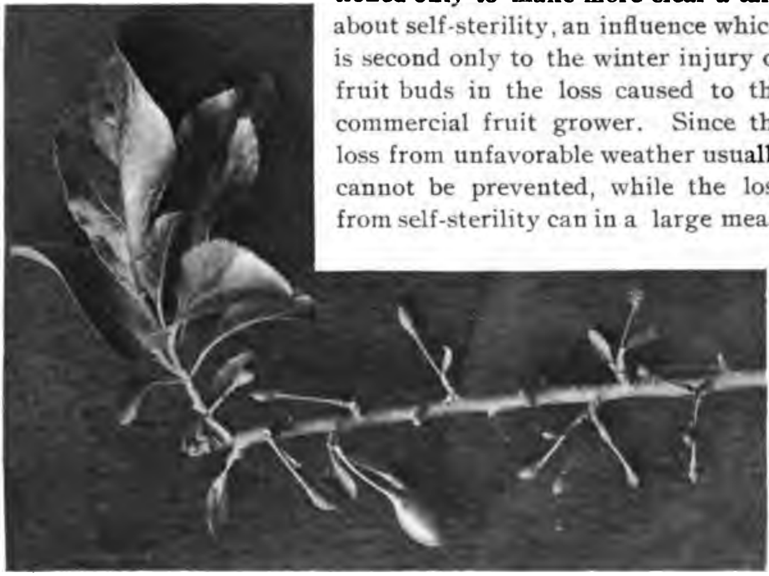
Thus a rain during the blooming season may decrease the setting of fruit in four ways: (1) By preventing the pollen from reaching the stigma, both because it is too wet to fly and because pollen-carrying insects are absent. This is important only when the rain lasts several days and most of the pistils pass their receptive state before the rain ceases. (2) By destroying the vitality of the pollen. (3) By injuring the stigma. (4) By preventing fertilization or the germination of the pollen because of low temperature.

The blossoms may be injured by strong or drying winds.

Near the sea and large lakes, fruit blossoms may be whipped off by very severe winds. In such cases a mixed windbreak of deciduous and evergreen trees may be used to advantage. Drying winds during the blossoming season are not common in the east but are often serious in some parts of the west. Luther Burbank, one of our best observers and experimenters in orchard pollination, says a dry wind sometimes causes a short fruit crop in some parts of California by drying up the juices of the stigma so that the pollen cannot germinate.

II. SELF-STERILITY.

There have been described in the preceding pages some of the influences which decrease the setting of fruit. These were mentioned only to make more clear a talk about self-sterility, an influence which is second only to the winter injury of fruit buds in the loss caused to the commercial fruit grower. Since the loss from unfavorable weather usually cannot be prevented, while the loss from self-sterility can in a large measure, the latter subject deserves more than the brief notice which has been given to the former at this time.



79.—*Coe Golden Drop. But one fruit has set; the others will soon drop.*

There are some trees which blossom full year after year but set little or no fruit, even in the most favorable seasons. These trees are usually in solid blocks, or at a distance from any other variety. Planting near them other trees of the same variety does not make them fruitful; but if trees of other varieties are planted near they are often made fruitful. *A self-sterile variety is one which is unable to set fruit when alone: in order to be productive, it must be planted near some other variety.* Two varieties very commonly self-sterile are Miner and Wild Goose plums. Large blocks of the Kieffer pear and some of the great prune orchards on our Pacific coast have been unprofitable from this cause. Besides these striking examples, there is reason for believing that much of the unsatisfactory fruiting of orchards all over the country is due to the isolation or indiscriminate mixing of varieties.

The main cause of self-sterility.

In general, *the cause of self-sterility is that the pollen of a variety is unable to fertilize the pistils of that same variety.* That is, if pollen from a Wild Goose blossom falls on a Wild Goose pistil, whether on the same tree or any other Wild Goose tree, no fruit will result as a rule. The pollen of a self-sterile variety may be and generally is produced in abundance and is well formed. Wild Goose generally bears pollen freely, although it is one of the most self-sterile varieties in cultivation. The Bartlett pear is often self-sterile, yet its pollen is perfect. (Fig. 80.) The pollen of a self-sterile variety also has vitality, for it will fertilize the pistils of other varieties. For example, plant together trees of the two self-sterile varieties, Miner and Wild Goose, and both will often be made fruitful, because the pollen of each, though infertile on itself, is fertile on the other. It is not known in what way this infertility is usually shown, but with Wild Goose at least, the pollen grain actually germinates and the pollen tube passes down to the ovule. Why the two sexes are unable to unite after having got thus far, the embryologist has not yet told us.

80.—*Pollen of Bartlett. Much magnified.*

Minor causes of self-sterility.

Aside from the impotency of pollen, the main cause of self-sterility, there may be several other incidental causes. Goff and

Waugh have shown that self-sterile varieties of native plums often have a large per cent of pistils which are too weak to develop into fruit. This could not be a general cause of self-sterility, however, for self-sterile varieties can usually be made fruitful by planting other varieties near them. This shows that there are enough sound pistils on the tree for a good crop of fruit, provided they receive the right kind of pollen.

Again, the blossoms of some varieties may produce but a small amount of pollen. When these varieties are planted alone they may not have enough pollen to set a good crop, even though the pollen is fertile on its associated pistils. The amount of pollen which flowers produce is greatly modified by weather conditions and the vigor of the tree.

Many plums are worked on Marianna and Miner stocks, two of the most self-sterile varieties in common cultivation. It has been thought that possibly there might be an influence of the stock on the scion in the direction of self-sterility, but this assumption seems to be without foundation.

Finally, the stamens and pistils of a tree may not mature simultaneously, which would make a tree unfruitful unless pollen is supplied from other sources. With many varieties of orchard fruits the pistil of each flower matures a little before the stamens; and not infrequently the stamens mature before the pistil is ready to receive the pollen. But there is usually enough variation in the opening of flowers on the same tree to promote pollination with each other and so prevent serious loss from this alternate ripening of the sexes. Defective pistils, scanty pollen supply, and the premature ripening of either pistils or stamens may often be important in determining the fruitfulness of a tree; but the main cause of unfruitfulness in most self-sterile varieties is the failure of the pollen to fertilize its associated pistils. This cause cannot be removed, but its injurious results may often be prevented by a judicious selection of varieties.

A practical application.

The practical bearing of the self-sterility problem is this: There are certain varieties of fruit which we wish to grow largely for the general market, but we find that they are not productive when planted alone. They need the pollen of other varieties to make them fruitful. Then we must do what some of our most intelligent fruit-growers have been doing for years—plant other varieties near them as pollinizers. Orchardists along the Atlantic coast have been obliged to do this with Kieffer. The Californians often find it necessary with their prunes; and many an unproductive orchard of Wild Goose has been made fruitful by being partially top-worked with another variety. Cross-pollination of varieties is no longer a theory; it is an established orchard practice.

The history of the self-sterility discussion.

There are at least sixty species of plants which are known to be often sterile with their own pollen. The study of this problem had its origin mainly in the investigations of Darwin. While Darwin was not the first to observe the value of cross-pollination, he so far exceeded his predecessors in this, as in most other work, that the beginning of a systematic study of self-sterility is usually dated from the publication of his "Origin of Species" in 1859. Self-sterility in orchard fruits was first studied by Waite, under the direction of the United States Department of Agriculture. Since the publication of his work, in 1894, (Bul. 5, Div. Veg. Pathology) many experimenters have continued the lines of study indicated by him.

The unfruitfulness arising from self-sterility had been noticed many years before by fruit growers. The benefit which some varieties gained by being planted near other varieties also had been noticed, and mixed planting was often practiced with success, particularly with Wild Goose and Miner. There are now one hundred and twenty-six entries in my bibliography of references to "barren" trees in American literature before the appearance of Waite's bulletin in 1894. The real cause of this barrenness, however, was not known definitely before the experiments of Waite; although it had long been supposed by many to be the pollen. Of late years, many experimenters have done careful work along this line. Among these are Goff, Waugh, Craig, Kerr, Crandall and Heideman on orchard fruits; Beach, Earle, T. V. Munson, Whitten, and Green on grapes. The California and Oregon State Boards of Horticulture are also making a special inquiry on the self-sterility of prunes.

Varieties which are often self-sterile.

Self-sterility is not a constant character with any variety. It is influenced by the conditions under which the tree is grown, as are the size, shape and color of the fruit. The adaptation of a variety to soil and climate has much to do with its self-fertility, and if a tree is poorly nourished it is more likely to be infertile with its own pollen. No one can separate varieties of fruit into two definite classes, the self-sterile and the self-fertile. Thus Bartlett and Kieffer are often self-sterile, but there are orchards of both which are self-fertile. The same may be said of many other varieties. The best that can be done, therefore, is to give a list of those varieties which *tend* to be more or less self-sterile and which it would be unsafe to plant alone.

Following is a conservative list of these risky varieties, drawn both from experimental work and from the reports of over five hundred fruit growers who have favored me with their experience. *Pears:* Angouleme (Duchess), Bartlett, Clapp, Idaho, Kieffer, Nelis. *Apples:* Bellflower, Primate, Spitzenburg, Willow Twig, Winesap. *Plums:* Coe Golden Drop, French Prune, Italian Prune, Kelsey, Marianna, Miner, Ogon, Peach, Satsuma, Wild Goose, and according to Waugh and Kerr, all other varieties of native plums except Robinson. *Peach:* Susquehanna. *Apricot:* White Nicholas. *Cherries:* Napoleon, Belle de Choisy, Reine Hortense. Most of these varieties are self-fertile in some places, but the weight of evidence shows them to be uncertain.

It must not be inferred that all other varieties are always able to set fruit when planted alone. There are some, however, which have exceptionally good records for fruitfulness when planted in solid blocks, other conditions being favorable. Among these are: *Apples:* Baldwin, Ben Davis, Fallawater, Janet, Oldenburg, Rhode Island Greening, Red Astrachan, Smith Cider. *Plums:* Burbank, Bradshaw, DeSoto, Green Gage, Lombard, Robinson and some of the common blue Damsons.

All this goes to show that the problem of self-sterility is as much a study of conditions as of varieties. We can set no limits; we can only indicate tendencies.

The great and growing Kieffer pear industry in the eastern United States warrants a fuller discussion of this variety. Many large blocks of Kieffer are being planted with no other varieties intermingled, and it is an important point to know whether this practice will give the best results. Eight blocks of Kieffer in New Jersey and Delaware have been reported as completely or partially unfruitful because of self-sterility, and there are also many solid blocks of Kieffers in the same states which bear well. Kieffer is unreliable, especially on the Delaware peninsula. A large block of Kieffer may be productive, but it does not pay to take the risk, particularly since the pollen of other varieties is likely to give better fruit, as will be seen later on.

Selecting the pollinizer.

Let us suppose that we intend to plant a large block of an uncertain variety, as Kieffer, because it has distinct merit as a market sort. We wish to plant with it some other variety to make it fruitful. There are two points to be considered when selecting a pollinizer for Kieffer or for any other self-sterile variety; the choice should not be indiscriminate. These are simultaneous blooming, and mutual affinity.

The first and most important point is that the two shall blossom together, since the only way in which a pollinizer can make a self-sterile variety fruitful is by supplying it with pollen. This means that the pistils of the self-sterile variety must be receptive when the stamens of the pollinizer are ripe, which is possible only with simultaneous blooming.

The comparative blooming of varieties is more or less a local problem. Differences of latitude, altitude, soil, nearness to large bodies of water, and weather conditions during the blooming season not only hasten or retard the time of blooming but also disturb the order in which the different varieties open. Varieties blossoming together at one place may not at another. The best that can be done in the way of generalizing on the question of simultaneous blooming for cross-pollination is to make a chart for each well marked geographical district. To this end several hundred fruit growers have kindly taken notes the past two seasons, and when sufficient data is collected these charts may be published. They will indicate in a general way which of our standard commercial varieties may be expected to bloom together; yet each fruit grower should be prepared to make minor corrections for his own farm. Until more definite knowledge is available, each orchardist should learn how varieties bloom in his own neighborhood before planting them for cross-pollination. It is better, but not always necessary, that the two should bloom exactly together; if they overlap two or three days that is often enough.

It is sometimes desirable to plant varieties of different botanical species together for cross-pollination, but this will often be impracticable because of the difference in their blooming seasons. Thus the Oriental pears, as Kieffer, and the European pears, as Bartlett, usually do not blossom together. Kieffer generally blooms several days before Bartlett, hence it is necessary to pollinate it with a variety of its own class, as Le Conte or Garber. In some places, however, the two groups blossom approximately together, and then varieties like Bartlett and Seckel should be used in preference to Le Conte or Garber, since their fruit has a greater market value and the trees are less likely to blight. Whenever the European pears are used as pollinizers for Kieffer it would be well, if otherwise practicable, to work them on quince roots. Standard Kieffers will often bloom two or three years before standard Bartletts planted at the same time, and unless early blooming dwarfs are intermingled they may be unproductive these first few years.

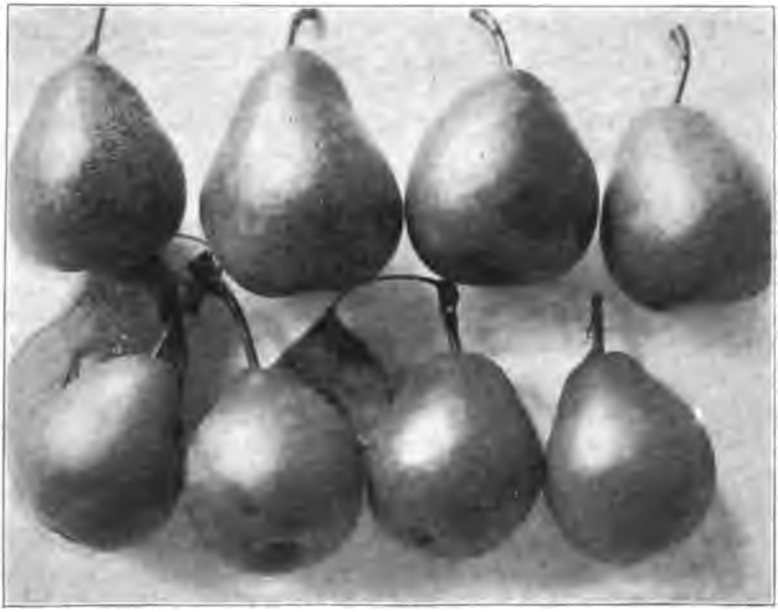
The three classes of commercial plums,—Japanese, domestica and native,—will usually bloom at different periods in the order named; but when a "spell" of warm weather succeeds a cold and backward spring, varieties of all these groups will come on nearly together and cross-pollination will result. In some places the blooming seasons of these groups overlap so that some varieties of each might be used regularly for cross-pollination.

The mutual affinity of varieties.

Another point to be looked after when selecting a pollinizer for Kieffer, or for any other self-sterile variety, is the mutual affinity of the two. That is, will the pollen of the pollinizer fertilize the pistils of the self-sterile variety readily and also develop them into high grade fruit? At present but little is known about this matter. Taking first the possibility of cross-pollination between varieties of different species, there seems to be no doubt but that many varieties of native, Japanese and domestic plums will fertilize each other. Orchard experience in many places indicates this; as when Satsuma is used to pollinate Coe Golden Drop in Californian prune orchards. Several successful crosses between the three were also made at Ithaca the past season. Among these are Abundance × Grand Duke (Fig. 84), Georgeson × Wayland, Berckmans × Coe Golden Drop, Coe Golden Drop × Satsuma. That is, if we wish to use Satsuma as a pollinizer for Coe Golden Drop, or Lombard for Wild Goose, the probability is that the combination would work, if the two varieties bloom together; but since the three groups usually bloom at somewhat different periods there can be no general cross-pollination outside the limits of the species.

Numerous crosses and common orchard practice have also shown that the European pears, as Bartlett, and the Sand Pear hybrids, as Kieffer, will fertilize each other regularly when they bloom together. Several Kieffer fruits from Bartlett pollen and Bartlett fruits from Kieffer pollen were secured in the crossing work of 1899. In fact, my experience has been that if Kieffer pollen is put on the pistils of our common pears, of the European class, it will usually produce larger fruit than pollen from most varieties of that type. Kieffer is a good pollinizer for Bartlett, Angouleme, Clapp, Nelis and like varieties, when they bloom together. In Fig. 81, compare the size of the Seckels which received Kieffer pollen with those which had Lawrence pollen. The specimens shown are typical of thirty fruits secured from these two crosses in 1899.

It is necessary to study not only the mutual affinity of varieties belonging to different species, but also of varieties of the same species. Some varieties will not fertilize each other, though blossoming at the same time. Kerr has found that Whitaker plum will not fertilize Wild Goose nor will Early Red help Caddo Chief. Again, the pollen of some varieties will give better fruit than that of others when used on the pistils of self-sterile or even on self-fertile varieties. There is very little definite knowledge as to what varieties are best adapted for pollinating self-sterile sorts. Waugh and Kerr have studied this point with native plums for several years and their judgment is united in a table of recommended pollinizers for plums (12th Report Vt. Ag. Ex. Sta.). A few results from crosses made at Ithaca in 1899 will illustrate this point. Fig. 81 shows the comparative size of Seckel when pollinated with Kieffer and with Lawrence pollen. Clapp pollinated with Kieffer was also larger than Clapp pollinated with Lawrence or Louise Bonne., Howell blossoms which received the pollen of Clapp gave fruits of nearly twice



81.—*Seckel. From Kieffer pollen above, from Lawrence pollen below.*

the size of those which received Bartlett pollen. Bartletts crossed with Angouleme were larger than Bartletts crossed with Sheldon. In some cases no difference could be noticed, yet most of our standard commercial varieties will be likely to yield enough better fruit when planted with some varieties than with others, to make a study of this point worth the while.

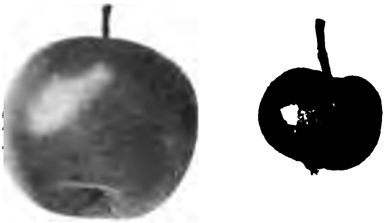
Some of the combinations which have been very successful in the commercial orchards of the country are: Bartlett with Nelis, Flemish Beauty, Easter, White Doyenne; Idaho with Bartlett; Kieffer with LeConte, Garber; Coe Golden Drop with French Prune, Green Gage, Italian Prune (Fellenburg); Statsuma with Abundance, Burbank, Red June; Miner with DeSoto, Forest Rose, Wild Goose; Wild Goose with De Soto, Newman, Miner.

Does crossing change the appearance of the fruit?

In connection with the mutual affinity of varieties which are selected for cross-pollination, there comes the question of the "immediate influence" of pollen. For instance, if Seckel pollen is put on Kieffer pistils, will it impart the Seckel flavor, color and characteristic shape to the resulting fruit? Of course the characters of both may be united in the seeds, and the trees which come from these seeds may be expected to be intermediates; but is the flesh of the fruit ever changed by foreign pollen?

The increase in size which often follows crossing cannot be called a true immediate influence, for the foreign pollen generally stimulates the fruit to a better growth because it is more acceptable to the pistils, not because it carries over the size-character of the variety from which it came. In 1899, Hyslop Crab pistils which were fertilized with pollen from the great Tompkins County King, grew into fruits of the usual crab size. An immediate influence in size may be possible, for the size of the fruit is nearly as constant a varietal character as is the shape; but most of the increased size in crosses of orchard fruits probably arises from the fact that the pollen is more acceptable.

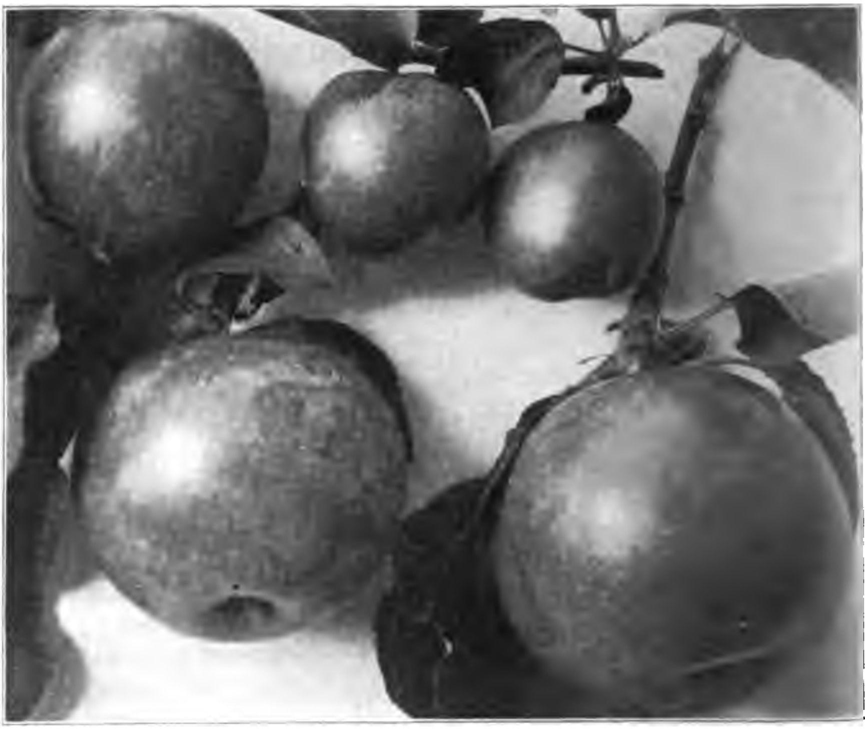
Setting aside the usual gain in size resulting from crossing, we wish to know whether there will be any change in the shape, color, quality and season of ripening of the fruit. A few undoubted instances of this influence have been noticed with some plants in which the seed is the principal part of the fruit, as the mixing of sweet corn and field corn; also perhaps in various peas and beans. When the seed is surrounded by a fleshy pulp, however, as in our common orchard fruits, it is still in dispute whether this pulp is influenced, however much the seeds themselves may be. Most men have formed their convictions about the immediate influence of pollen from observation, rather than from experimental proof. It does not necessarily follow that "sweet and sour" apples are due to cross-pollination, nor that the russet on Greening apples borne on the side of the tree next a Roxbury was produced by the influence of the Roxbury pollen.



82.—*Stark. From Wagener pollen above, from Stark pollen below. Marked benefit from cross-pollination.*

Most of the changes in fruit which are attributed to the influence of cross-pollination are due to variation. Every bud on a tree is different in some way from every other bud on that tree and may develop unusual characters, independent of all the other buds, according to the conditions under which it grows.

The best way to determine whether there is an immediate influence of pollen is by hand crossing. Among the forty-five different crosses which were made in 1899 with this particular point in view, not one showed any change which could be positively attributed to the influence of pollen. Even the concentrated sweetness of Seckel made no impression on the poor quality of Kieffer; nor were there any constant differences in color, shape, or season of ripening in any of the other crosses. Nearly everybody who has crossed varieties of orchard fruits has had a similar experience.

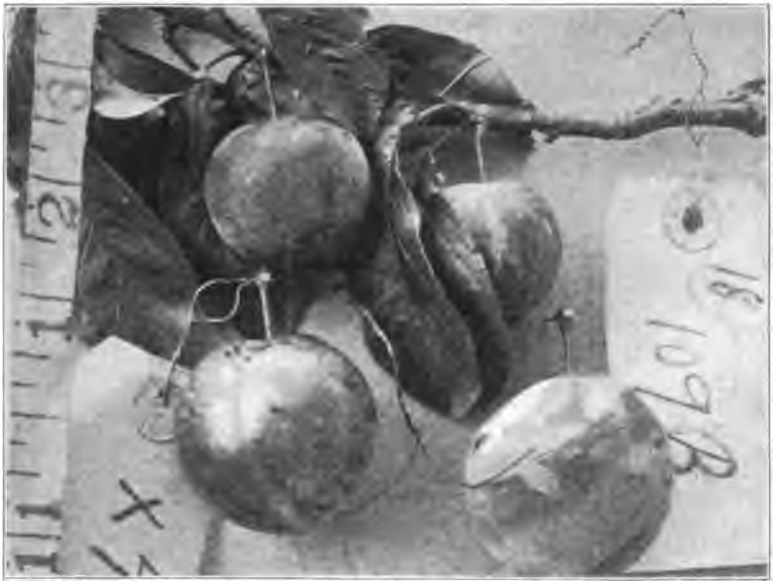


83.—*Longfield. From Greening pollen below, from Longfield pollen above. Marked benefit from cross-pollination.*

Most of the evidence supporting the theory that there is an immediate influence of pollen in the crosses of fruits comes from observation; most of the evidence against it comes from experiment. The observer, however careful, is likely to jump at conclusions; the experimenter tries to give due weight to every influence which might bear on the problem. Since many observers and a few experimenters have found what seems to be an immediate influence of pollen on the fruit, we cannot doubt but that this influence is sometimes exerted. But it is certainly much less frequent than is commonly supposed.

The distribution of the pollinizers.

Having selected a pollinizer with reference to simultaneous blooming and mutual affinity, the fruit-grower now wishes to know how many trees will be necessary to pollinate the self-sterile variety. There are three things to be considered here: the ability of the pollinizer to produce pollen, its market value, and the class of fruit to which the self-sterile variety belongs.



84.—*Abundance. From Abundance pollen above, from Grand Duke pollen below. Some benefit from cross-pollination.*

Varieties differ in the amount of pollen which they produce, and the pollen production of the same variety is also greatly modified by differences in locality and season. Other things being equal, the variety which produces pollen freely could be used more sparingly in a block of self-sterile trees than one of scanty pollen production. Little comparative observation has been made on this point as yet; but as a matter of fact, most of our common varieties produce an abundance of pollen.

The number of trees of the pollinizer would also depend largely on whether it has value in itself. If we are planting LeConte to pollinate Kieffer, we would naturally try to get along with the least possible number which will do the work; but if Bartletts are to be used for the same purpose, we can afford to increase the proportion. Some growers plant every tenth row to the polli-

85.—*Talman Sweet. From Talman Sweet pollen above, from Wagener pollen below. No benefit from cross-pollination.*

nizer, but the proportion should usually be greater. This might be enough if the weather during the blossoming season is very favorable for cross-pollination by wind and insects; but if it is showery, the pollinizers should be more abundant, in order that cross-pollination may be more general during the bright weather between showers. If using Garber or LeConte to pollinate Kieffer, every third row may be the pollinizer; if using Bartlett, every other row. For apples, cherries and domestic or Japanese plums, the same proportion may be used. In a commercial orchard, the pollinizer should be planted in a solid row. Theoretically, it is much better to have the pollinizer more evenly distributed among the self-sterile trees; practically, it will not pay to so mix them except in small orchards.

86.—*Bradshaw Plum. From German Prune pollen above, from Bradshaw pollen below. No benefit from cross-pollination.*

The advantages of general mixed planting.

It would appear that the only thing to do now is to find out what varieties are inclined to be self-sterile and the varieties which are best adapted for fertilizing them. But as a matter of fact, cross-pollination gives better results with nearly all varieties, be they self-sterile or self-fertile. A variety may be able to bear good fruit when it is planted alone, but it will often bear better fruit if suitable varieties are near it. Mixed orchards are more productive than solid blocks, taking the country over. It is a common observation in Western New York that Baldwins in mixed orchards are more uniformly productive than Baldwins in large blocks. Furthermore, although a variety may be able to set an abundance of fruit with its own pollen, this fruit will often be smaller than if other pollen were supplied. From a number of experiments made in 1899, a few representative results are here given to illustrate this point.

Compare the size of self-pollinated and cross-pollinated fruits in Figs. 82–86. In some varieties the difference was very marked, as with Stark and Longfield apples (Fig. 82–83); in others the difference was not so marked, as Abundance (Fig. 84); while a few showed no appreciable increase in size from cross-pollination, as Talman Sweet and Bradshaw (Fig. 85–86). The difference between the cross- and self-pollinated Starks and Longfields is so striking that one would almost be tempted to think the self-pollinated fruits were wormy, but they were not. The self-pollinated Talmans and Bradshaws were apparently as fine in every way as the cross-pollinated fruits. Manning Elizabeth pear also was not benefited by pollen from other varieties.

The three self-pollinated Longfields here shown (Fig. 83) had but five sound seeds; while the two crossed specimens had seventeen sound seeds. In general, cross-pollinated fruits have more good seeds than self-pollinated fruits, but there is no constant relation between the size of a fruit and the number of seeds it contains. Some of the biggest apples or pears may have only two or three good seeds. In case the ovules in one cell of an apple or pear core are not fertilized, that part of the fruit adjoining is often stunted and the fruit becomes lop-sided in consequence; but this, likewise, does not always follow.

All of the above varieties are self-fertile, at least in Ithaca. They will produce fruit with their own pollen. But we have seen that some of them will produce better fruit if other pollen is supplied. Is it not worth while, then, to plant pollinizers even with self-fertile varieties—that is, to practice mixed planting with all varieties? There are three good reasons for doing this: First, some believe that self-sterility is likely to increase in the future, under the stimulus of high cultivation. Second, we can never be perfectly sure that any variety will be self-fertile on our soil and under our culture; even those varieties which are self-fertile elsewhere may be partially self-sterile with us. Third, most self-fertile as well as self-sterile varieties are benefited by cross-pollination. It is taking risks to plant a very large block of one variety. The trees may bear just as much and just as fine fruit as though other varieties were with them, but the chances are against it.

The pollen-carriers.

The pollen of one variety is carried to the pistils of another in two ways: by the wind and by insects. There are many kinds of insects which aid more or less in the cross-pollination of orchards fruits, principally bees, wasps and flies. Of these, the wild bees of several species are probably the most important. In a wild thicket of plums or other fruits, they are usually numerous enough to insure a good setting of fruit. But few if any wild bees can live in a large orchard, especially if it is well tilled. As the extent and thoroughness of cultivation increases, the number of these natural insect aids to cross-pollination decreases; hence it may become necessary to keep domestic honey bees for this purpose.

SUMMARY.

1. Scarcely one fruit blossom in ten sets fruit, even in the most favorable seasons and with the most productive varieties.

2. Trees making a very vigorous growth may drop their blossoms.

3. Brown rot, apple or pear scab, and pear blight may kill the blossoms.

4. Frost injury to blossoms is of all degrees. Even flowers which appear to be uninjured may be so weakened that they cannot set fruit.

5. Rain during the blooming season prevents the setting of fruit chiefly by destroying the vitality of the pollen, injuring the stigma, or by preventing fertilization because of the low temperature. The washing of pollen from the anthers seldom causes serious loss.

6. Much of the unsatisfactory fruiting of orchards all over the country is due to self-sterility. A tree is self-sterile if it cannot set fruit unless planted near other varieties.

7. The main cause of self-sterility is the inability of the pollen of a variety to fertilize the pistils of that variety.

8. Poor stamens and pistils or the premature ripening of either are but minor causes of self-sterility.

9. An indication of self-sterility is the continued dropping of young fruit from isolated trees or solid blocks of one variety.

10. Self-sterility is not a constant character with any variety. The same variety may be self-sterile in one place and nearly self-fertile in another.

11. Poorly nourished trees are more likely to be sterile with their own pollen than well fed trees are.

12. The loss of fruit from self-sterility usually may be prevented by planting other varieties among the self-sterile trees.

13. The European and Oriental pears can fertilize each other, and many varieties of the domèstica, Japanese and native plums are likewise inter-fertile, provided they bloom together.

14. The pollen of some varieties will give larger fruit than that of others when it falls on or is applied to the pistils of either self-sterile or self-fertile varieties.

15. Among our common orchard fruits cross-pollination seldom has an immediate influence on of the fruit itself.

16. Cross-pollination probably gives better results than self-pollination with nearly all varieties.

17. It is advisable and practicable to plant all varieties of orchard fruits, be they self-sterile or self-fertile, with reference to cross-pollination.

18. Insects are probably more important than wind for carrying pollen from tree to tree.

19. *Final suggestions.*—a. When setting out new orchards do not plant a solid block of each variety, but mix them intelligently.

b. If established orchards are unfruitful because of self-sterility it may be profitable to put a few grafts of another variety in each tree.

c. Keep fruit trees well nourished but do not stimulate them to an over-vigorous growth.

S. W. FLETCHER.

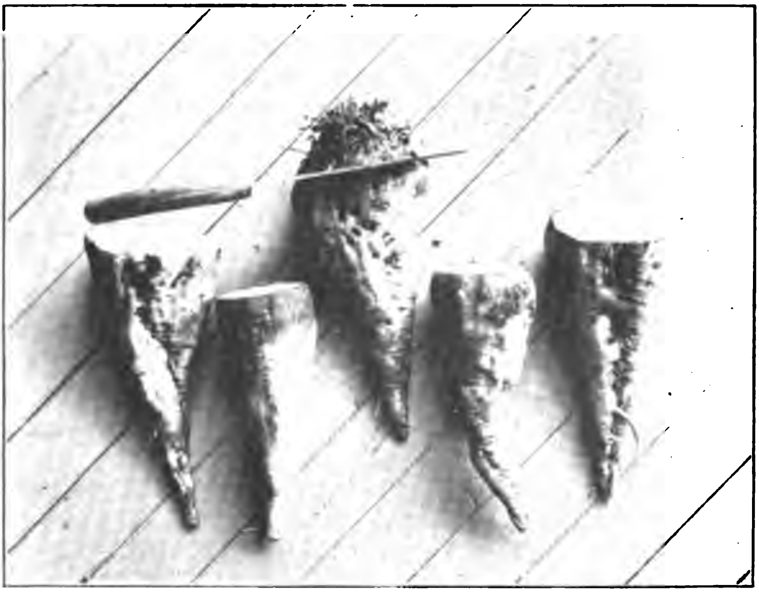
Bulletin 182. [redacted]ril, 1900.

Cornell University Agricultural Experiment Station.

ITHACA, N. Y.

AGRICULTURAL DIVISION.

Sugar Beet Investigations for 1899



By J. L. STONE and L. A. CLINTON.

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CORNELL UNIVERSITY, ITHACA, N. Y., March 15, 1900.

HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir:—The following report contains the results obtained from the coöperative experiments with sugar beets throughout the state, and also the results obtained upon the experimental grounds at Cornell University. The coöperative experiments were in charge of Mr. J. L. Stone, and consisted of making tests of varieties and also of fertilizers. Owing to peculiarities of the season the fertilizer work is not here reported, but a full account is given of the test of varieties. This coöperative work with the farmers throughout the state is valuable not only for the results obtained from the experiments, but also for the interest which it creates among the farmers in the work which is being done by the state through the College of Agriculture, and by the Experiment Station to advance the cause of agriculture.

The work upon the home grounds was in charge of Mr. L. A. Clinton. Experiments have been conducted with fertilizers upon sugar beets, and a summary of the work for three years is given. This report is of value owing to the care taken to make the plats uniform and to the length of time during which the experiment has been conducted. An account is also given of the field plat experiments with sugar beets during 1899.

The data obtained add to our knowledge of the subject of sugar beet growing, and the report is submitted for publication under Chapter 430 of the Laws of 1899.

I. P. ROBERTS,
Director.

PART I. CO-OPERATIVE EXPERIMENTS.

BY J. L. STONE.

The investigations relating to sugar beets conducted by this station during the season of 1899 have been chiefly along the lines of comparison of varieties, and testing the effect of different fertilizers on the yield and quality of beets. No effort was made to locate experiments outside the territory that is producing beets for the two factories now in operation in the state. However, requests were received from some thirty persons living in other sections asking for seeds and instruction for growing beets, both of which were forwarded, and the beets received from such persons have been tested for sugar and purity.

Arrangements were made with thirty-eight farmers who were engaged in sugar beet culture, and therefore vitally interested in the work, to make a practical comparative test of five varieties of sugar beets, the seed of which was furnished to the station by the U. S. Department of Agriculture, Washington, D. C. By having the five varieties grown side by side, and thus under as nearly uniform conditions as to fertility and culture as possible in each of the experiments, it was believed that the average results obtained would be much more significant than a larger number of tests where the varieties were separated and perhaps subjected to different conditions.

In previous work it has been the custom of the station to receive two beets as a sample for determining the percentage of sugar and purity of the juice. It is frequently observed when these beets are examined separately that they show considerable difference in content of sugar and purity of juice, thus leading to the conclusion that the individuality of the beet may lead to an erroneous estimate of the crop where so few as two beets are used as a sample. It was therefore decided that each sample should consist of six beets, which were forwarded by express, instead of through the mails as formerly, thus materially reducing the liability to error from the cause mentioned.

The season for preparing the land and sowing was unusually favorable so that the seed was gotten in the soil in fine condition and at an early date. In fact the early date at which the seeding was completed had the effect of reducing the number of our experiments, as we had expected at least two weeks more time in which to go among the farmers to arrange the work. The weather conditions were favorable for germination, a good stand was obtained and early and economical tillage was generally facilitated so that up to the middle of August the crop was unusually promising. From this time on the effect of drought, which in some localities was the most destructive on record, was very manifest. In some instances the damage was so great that the experiment was abandoned as not likely to give trustworthy data. In fact it is believed that abnormal conditions of any kind, and especially drought, lessen the value of experimental data, as they emphasize the unavoidable inequalities of soil as regards texture, natural water supply, etc.

The variety tests—The following table No. 1, gives a statement, somewhat in detail, of the results obtained by each experimenter. The table gives the name and address of the grower, the character of the soil, the varieties of beets grown, the yield per acre in tons, the percentage of sugar in the beets and the purity of the juice.

All analyses recorded in this bulletin were made by Mr. G. W. Cavanaugh and Mr. A. L. Knisely, Assistant Chemists of the Experiment Station.

TABLE I.

Name and Address of Grower.	Character of Soil.	Variety of Beets.	Tons per Acre.	Sugar per cent. in Beets.	Purity of Juice.
Robert Wright, Little York, Cortland Co., N. Y.	Gravelly	Kleinwanzlebener	11.90	15.96	82.4
		Vilmorin	11.55	14.35	77.4
		Zehringen	10.75	15.01	81.9
		Mangold	13.30	12.92	75.6
		*Biendorf Elite Klein.	10.75	13.30	76.9
F. E. VanCamp, Preble, Cortland Co., N. Y.	Gravelly	Kleinwanzlebener	10.89	18.15	84.9
		Vilmorin	9.15	17.48	85.2
		Zehringen	10.02	18.72	87.5
		Mangold	9.80	17.53	85.4
		Biendorf Elite Klein.	9.80	17.29	84.0
Frank Daley, Preble, Cortland Co., N. Y.	Gravelly loam	Kleinwanzlebener	9.24	19.00	85.8
		Vilmorin	13.20	17.48	82.5
		Zehringen	10.06	18.81	83.3
		Mangold	12.20	17.77	83.1
		Biendorf Elite Klein.	9.24	18.38	86.4
Clark Esty & Son, Tully Valley, Onondaga Co., N. Y.	Gravelly loam	Kleinwanzlebener	17.10	17.72	86.7
		Vilmorin	14.25	14.54	79.7
		Zehringen	17.25	15.96	82.7
		Mangold	17.00	15.15	82.6
		Biendorf Elite Klein.	14.25	14.49	77.4
C. A. Knapp, Little York, Cortland Co., N. Y.	Gravelly loam	Kleinwanzlebener	7.46	12.26	72.9
		Vilmorin	7.86	11.50	69.9
		Zehringen	6.97	13.87	76.8
		Mangold	8.13	12.16	71.5
		Biendorf Elite Klein.	7.39	10.64	66.7
W. E. Bowen, Little York, Cortland Co., N. Y.	Gravelly loam	Kleinwanzlebener	13.45	17.86	87.0
		Vilmorin	16.80	16.77	84.9
		Zehringen	13.90	16.48	83.0
		Mangold	14.90	16.34	82.7
A. A. Knapp, Preble, Cortland Co., N. Y.	Sandy loam	Kleinwanzlebener	13.80	15.20	76.5
		Vilmorin	15.80	16.10	76.7
		Zehringen	12.90	18.15	80.2
		Mangold	14.80	16.44	79.7
		Biendorf Elite Klein.	14.80	14.49	76.7
G. H. Thomas, Chenango Bridge, Broome Co., N. Y.	Sandy loam	Kleinwanzlebener	8.80	15.77	82.6
		Vilmorin	8.16	14.87	83.2
		Zehringen	7.96	13.82	80.4
		Mangold	10.66	15.34	80.8
		Biendorf Elite Klein.	9.43	13.63	77.6

* Biendorf Elite Kleinwanzlebener.

TABLE I—*Continued.*

Name and Address of Grower.	Character of Soil.	Variety of Beets.	Tons per Acre.	Sugar per cent. in Beets.	Purity of Juice.
Wm. Weale, Owego, Tioga Co., N. Y.	Sandy loam	Kleinwanzlebener	10.10	14.25	78.6
		Vilmorin	10.40	9.83	72.9
		Zehringen	8.85	14.63	79.4
		Mangold	10.00	15.20	82.8
		Biendorf Elite Klein.	11.85	12.92	73.1
O. B. Wilmot, Chenango Bridge, Broome Co., N. Y.	Sandy loam	Kleinwanzlebener	13.50	14.25	82.0
		Vilmorin	11.20	12.92	79.5
		Zehringen	12.90	15.58	84.1
		Mangold	15.05	14.39	81.5
		Biendorf Elite Klein.	12.60	13.82	85.2
John J. Smith, Candor, Tioga Co., N. Y.	Loam	Kleinwanzlebener	11.00	14.39	80.6
		Vilmorin	10.75	12.87	77.0
		Zehringen	11.85	15.20	80.4
		Mangold	10.70	14.44	80.9
		Biendorf Elite Klein.	11.25	13.30	78.2
Edwin Lawrence, Binghamton, Broome Co., N. Y.	Loam	Kleinwanzlebener	15.00	14.96	82.9
		Vilmorin	12.50	14.06	80.0
		Zehringen	12.50	15.01	82.7
		Mangold	15.00	14.54	82.3
		Biendorf Elite Klein.	16.25	13.73	78.9
C. J. Banta, Conklin, Broome Co., N. Y.	Upland loam	Kleinwanzlebener	7.00	17.01	84.4
		Vilmorin	8.00	18.05	86.8
		Zehringen	6.66	18.86	87.4
		Mangold	7.50	16.63	88.4
		Biendorf Elite Klein.	6.00	17.48	87.2
Jessel Hall, Chenango Bridge, Broome Co., N. Y.	Loam	Kleinwanzlebener	12.50	14.77	82.3
		Vilmorin	9.50	13.02	77.4
		Zehringen	10.50	13.63	79.7
		Mangold	10.50	13.30	77.8
		Biendorf Elite Klein.	9.00	13.59	77.3
H. E. Parsons, Chenango Bridge, Broome Co., N. Y.	Alluvial loam	Kleinwanzlebener	16.39	13.16	78.2
		Vilmorin	12.03	14.49	81.6
		Zehringen	13.88	15.68	82.9
		Mangold	14.34	13.30	77.3
		Biendorf Elite Klein.	14.34		
P. Judson Peck, Sherburn, Chenango Co., N. Y.	Loam	Kleinwanzlebener	12.05	16.82	83.5
		Vilmorin	13.34	15.20	78.4
		Zehringen	13.06	16.29	82.9
		Mangold	14.10	15.91	83.3
		Biendorf Elite Klein.	14.10	16.10	80.7

TABLE I—*Concluded.*

Name and Address of Grower.	Character of Soil.	Variety of Beets.	Tons per Acre.	Sugar per cent. in Beets.	Purity of Juice.
L. J. English, Binghamton, Broome Co., N. Y.	Black loam	Kleinwanzlebener	17.04	13.40	82.4
		Vilmorin	13.92	14.11	83.4
		Zehringen	16.00	15.06	82.6
		Mangold	17.25	13.87	82.0
		Biendorf Elite Klein.	17.92	14.44	82.2
W. C. Smith, Candor, Tioga Co., N. Y.	Gravelly loam	Kleinwanzlebener	7.50	13.82	80.8
		Vilmorin	8.32	12.21	77.4
		Zehringen	7.50	13.02	78.7
		Mangold	8.75	13.82	81.3
		Biendorf Elite Klein.	8.12	12.25	82.0
A. C. Bethka, East Syracuse, N. Y.	Loam	Kleinwanzlebener		16.34	85.6
		Vilmorin		15.72	84.9
		Zehringen		16.25	85.9
		Mangold		15.72	84.0
		Biendorf Elite Klein.		13.40	79.2
Geo. Lamb, East Hamilton, N. Y.	Mucky loam	Kleinwanzlebener		14.58	79.5
		Vilmorin		16.86	82.7
		Zehringen		15.63	82.7
		Mangold		16.72	84.2
		Biendorf Elite Klein.		15.96	81.5
T. S. Mulaney, Poolville, N. Y.	Loam	Kleinwanzlebener	7.19	12.83	75.8
		Vilmorin	4.91	14.06	75.9
		Zehringen	7.58	15.39	79.0
		Mangold	8.92	16.20	82.8
		Biendorf Elite Klein.	5.80	12.35	76.0
T. J. Collier, Preble, Cortland Co., N. Y.		Kleinwanzlebener		14.73	76.4
		Vilmorin		15.34	80.0
		Zehringen		16.06	79.0
		Mangold		14.25	77.0
		Biendorf Elite Klein.		11.40	69.5
S. W. Paddleford, Sherburn, Chenango Co., N. Y.	Loam	Kleinwanzlebener		14.48	82.4
		Vilmorin		14.35	81.2
		Zehringen		13.63	81.1
		Mangold		14.35	84.4
		Biendorf Elite Klein.		14.96	83.8
J. C. Fish, Corbettsville, Broome Co., N. Y.	Loam	Seed from Binghamton Beet Sugar Co		12.97	78.4
		Kleinwanzlebener		12.49	76.9
		Vilmorin		14.39	79.3
		Zehringen		14.92	80.1
		Mangold		14.01	80.6
		Biendorf Elite Klein.		14.44	82.6
		Lanes' Imp. Sugar		10.31	74.8

From an inspection of table No. 1 it may be seen that in the individual experiments important differences as to yield, content of sugar and purity of juice occur. These differences are sometimes sufficient to materially affect the profitableness of the crop, but the different varieties do not fall into any regular order as to yield or quality of crop. Each variety takes first place in some experiments and last in others.

Kleinwanzlebener	produces	largest	yield in	three	cases and	smallest in	four.
Vilmorin	"	"	"	four	"	"	eight.
Zehringen	"	"	"	two	"	"	seven.
Mangold	"	"	"	six	"	"	one.
Biendorf Elite Klein.	"	"	"	four	"	"	five.

A study of the kinds of soils upon which these experiments were conducted does not seem to indicate that any one of these varieties is preëminently adapted to a particular soil.

As regards quality of the beets it is also true that each variety takes first place in some experiments and last in others, but here there is a marked tendency for Kleinwanzlebener and Zehringen to appear at the head of the list, Vilmorin and Biendorf Elite Kleinwanzlebener to appear at the foot.

Kleinwanzlebener	shows	largest	% of	sugar in	ten	cases.	smallest in	four.
Vilmorin	"	"	"	"	one	"	"	seven.
Zehringen	"	"	"	"	ten	"	"	one.
Mangold	"	"	"	"	three	"	"	three.
Biendorf Elite Klein.	"	"	"	"	one	"	"	nine.

In some instances the highest content of sugar is associated with the largest yield but the tendency is to reverse this and associate high quality with low yield and vice-versa.

In table No. 2 are given the averages of the several varieties as set forth in table No. 1. The yields per acre are the averages for nineteen plats each growing the five varieties mentioned, except that Biendorf Elite Kleinwanzlebener was omitted from one plat. The columns showing the percentage of sugar and the purity of the juice are the averages for twenty-four plats each growing the five varieties except that the variety mentioned above was omitted from two of them.

TABLE NO. 2.—COMPARISON OF AVERAGE RESULTS.

Varieties.	Average Weight of Beets, Ozs.	Yields tons per acre.	Sugar in juice per cent.	Sugar in beets, per cent.	Purity of juice.	Sugar produced per acre, Lbs.
Kleinwanzlebener ...	16.1	11.67	15.75	15.16	81.2	3538
Vilmorin	15.7	11.14	14.80	14.07	79.9	3235
Zehringen	15.4	11.10	16.47	15.65	81.8	3474
Mangold	15.7	12.20	15.80	15.01	81.3	3662
Biendorf Elite Klein.	15.0	11.30	14.33	14.19	79.2	3207

While the average yield and quality of the different varieties of beets as shown in the above table are quite uniform, still between the highest and lowest there is a difference of more than one ton per acre in yield and above one and one-half per cent. in content of sugar.

A gain or loss of one ton per acre as resulting from the variety of beets planted is of very material importance to the farmer and a difference of one or one and a half per cent. of sugar in the beets is of even greater significance to the manufacturer.

It is estimated that a factory slicing during the season 25,000 tons of beets containing 15.5 per cent. sugar will turn out 3,250 tons of pure granulated marketable sugar, while if it were to slice the same amount of beets 1.3 per cent poorer in sugar, it would turn out 2,925 tons of marketable product—a difference of 325 tons of sugar which at $50.00 per ton would amount to $16,250. It will be seen that while in each case the expense incurred for beets, labor, fuel, etc., is the same, there is a difference in gross receipts for manufactured sugar amounting to a sum that will go a long ways towards a fair dividend on the investment.

Unfortunately, the variety showing the highest content of sugar (Zehringen) seems to be the lightest yielder. In our trials of 1898 (see Bulletin 166 pp. 135 and 136) this variety took the same rank when compared with Kleinwanzlebener and Vilmorin as to yield and quality that it does this season.

The variety of sugar beets known as Mangold was tested by this station for the first time this season and with very favorable results. As to productivity it heads the list and the quality is good. So far as the experience of this season on nineteen different farms may be an indication, it would seem that this variety might well be placed along with the well tried and ever reliable Kleinwanzlebener.

The fertilizer tests.—As stated at the beginning of this bulletin the plan of experimentation included a study of the effect of different fertilizing materia upon the yield and quality of sugar beets. Arrangements were made with a number of farmers to receive sets of experimental fertilizers from the station and apply them according to instructions. The scheme embraced eight plats of one-twentieth acre each as follows: Plat No. 1, 15 lbs. muriate of potash; plat No. 2, 15 lbs. nitrate of soda; plat No. 3, 30 lbs. superphosphate; plat No. 4, no fertilizer; plat No. 5, 15 lbs. muriate of potash and 15 lbs. nitrate soda; plat No. 6, 15 lbs. muriate of potash and 30 lbs. superphosphate; plat No. 7, 15 lbs. nitrate soda and 30 lbs. superphosphate; plat No. 8, 15 lbs. nitrate soda, 15 lbs. muriate of potash and 30 lbs. superphosphate; and, at the option of the farmer, plat No. 9, stable manure.

The conditions surrounding these experiments during the early part of the season were favorable and the prospect of securing valuable data seemed good up to the time that the drought became severe. As the season advanced it became evident that the real struggle of the plant was for moisture rather than for plant-food. Since it is impossible to secure nearly an acre of land that is perfectly uniform in texture and natural water supply it often occurs that the crop will vary more on account of these inequalities than from different fertilizers applied to the various parts. That commercial fertilizers may produce their full effect it is necessary that there be a liberal supply of moisture in the soil to take the plant-food thus furnished into solution. Hence it will be seen that the drought largely neutralized the effect of the fertilizer while it emphasized the inequalities of the soil. The data received from these experimenters are in some cases incomplete and owing to the effect of the drought it is considered unreliable and not valuable for publication.

PART II. SUGAR BEET EXPERIMENTS AT CORNELL UNIVERSITY EXPERIMENT GROUNDS, 1899.

BY L. A. CLINTON.

The land upon which the experiments were conducted was a part of the series of permanent plats. These plats have been subjected to intensive culture without the application of any fertilizer since the fall of 1893 when about ten tons of barn manure were applied per acre. Each fall after the removal of the crop from the land some cover crop as wheat or rye has been sown. But the lateness of the sowing prevented the cover crop from making much growth and as a consequence but little organic matter has been returned to the soil. The result is that the humus has been depleted and the soil, instead of remaining loose and friable, becomes very hard and compact under the action of rains. The fact is emphasized that where intensive culture is practiced, for best results it must be accompanied by a liberal application of barn manures or green manuring must be adopted, at least the organic matter of the soil must be maintained if the soil be kept in good physical condition.

The land for beets was plowed May 2—all except plat 27, which was plowed immediately before the beets were planted. After plowing the land was harrowed and rolled. Between time of plowing and time of planting the land was harrowed frequently.

Planting the beets.—On May 15 and 16 plats 21, 22, 23, 24, 26 and 27 were planted to variety Kleinwanzlebener, seed for which was furnished by the U. S. Dept. of Agriculture, Washington, D. C. Plat 27 was plowed deeply immediately before planting and harrowed and rolled. The object in leaving plat 27 without plowing until time of planting was to determine the effect of deep plowing immediately before planting. Plat 25 was planted to varieties—Mangold, Biendorf Elite Kleinwanzlebener, Vilmorins Improved and Zehringen. These plats were all planted with the rows 20 inches apart and the seed was covered to a depth of about one half inch.

Effects of a hailstorm.—Within a few days after planting and before the beets had appeared above ground a severe hailstorm occurred. The whole surface of the ground was covered with a layer of hail from one to two inches deep. The hail rapidly melted and the surface of the ground was made very wet. The effect upon the beets was most disastrous. The soil which had become depleted of its humus was compacted and the crust was so hard that the small beet plants were unable to force their way through. An attempt was made to break the crust by means of garden rakes, but the beet seed was covered so shallow that the plants were rooted near the surface and the soil directly over the young plants could not be disturbed without uprooting the plants and thus destroying them. It finally became apparent that a satisfactory stand of beets could not be secured upon all the plats and it was decided to plow and replant them so there would be secured a somewhat uniform stand of beets.

The second planting.—All beet plats were plowed June 5, and harrowed once with the spring tooth harrow and once with the spike tooth harrow and the beet seed was planted in rows 20 inches apart. Plats 21, 22, 23 and 24 were planted to Biendorf's Elite Kleinwanzlebener sugar beet seed. On plats 25, 26 and 27 there were planted fourteen rows of Zehringen Elite beet seed from Germany, grown by Dippe Brothers; twelve rows were planted to Zehringen Elite sugar beet seed from Germany, grown by Strandes; eight rows were planted to Zehringen beet seed and seven rows were planted to variety Mangold.

Object of experiment.—Upon plats 21, 22, 23 and 24 the object was to determine the effect upon the growth and yield of the beets of thinning at various times. With many farmers who grow beets for the factory it is often impossible to thin all the beets at the time of growth which has been recommended as most favorable. Owing to the large area to be thinned or to the pressure of other work the beets are often neglected for some time. Upon plats 25, 26 and 27 the experiment was simply a variety test.

Methods of tillage and thinning on plats 21, 22, 23 and 24.—The first tillage given the beets was on June 30 when a hand weeder was used on all plats. This weeder had the knife blade attach-ments which loosened the soil close to the plants and destroyed small weeds near the beets.

July 5th thinned to a stand the beets on the east one-half of plat 21 and on the east one-half of plat 22, and on plats 23, 24, 25, 26 and 27. The west one-half of plat 21 was permitted to remain without any thinning while the west one-half of plat 22 was bunched. On the west one-half of plat 21 the beets were allowed to remain thickly in the row until July 19 when they were thinned to a stand, there being left a space of about nine inches between beets in the row. On the west one-half of plat 22, the beets which had been bunched were permitted to remain in bunches until July 19 when they were thinned to a stand of one beet in a place. Tillage was given all plats on July 7, July 19 and July 25.

The thorough working of the land before the beets were planted tended to hasten their growth. The weed seeds which were present in the soil germinated before the second planting of the beets and were thus destroyed by the late plowing. The soil was thoroughly warm and owing to an abundant rainfall during July, 3.46 inches, the seeds germinated quickly and the plants grew rapidly.

The beets were not seriously injured by insects or disease. The growth of top was relatively small compared with the growth of root. To a casual observer the field never presented the appearance of having more than half a crop of beets.

Harvesting and yield.—The sugar beet harvest began November 3. A Syracuse chilled sub-soil plow was used to loosen the beets in the ground, after which they were trimmed by hand. The yield of trimmed beets from the various plats, also the per cent. of sugar and the per cent. purity are shown in the following table.

Plat No.	Variety.	Date of Planting.	Date of Thinning.	Yield Per Acre.	Per cent. Sugar in Beet.	Per cent. Sugar in Juice.	Purity.	Average weight of beets Analyzed.
21 East half	Biendorf's Elite Kleinwanzlebener	June 5	July 5	7.5 tons	15.49	16.30	82.8	12 oz.
21 West half	Biendorf's Elite Kleinwanzlebener	June 5	July 19	7.5 tons	14.82	15.60	80.8	13
22 East half	Biendorf's Elite Kleinwanzlebener	June 5	July 5	8.7 tons	14.06	14.80	79.6	11
22 West half	Biendorf's Elite Kleinwanzlebener	June 5	Bunched July 5 Thinned July 19	8.6 tons	15.01	15.80	83.2	13
23	Biendorf's Elite Kleinwanzlebener	June 5	July 5	10.1 tons	14.25	15.00	83.3	14
24	Biendorf's Elite Kleinwanzlebener	June 5	July 5	12.8 tons	15.34	16.15	82.1	12½
25	Zehringen Elite by Dippe Bros.	June 5	July 5	13.1 tons	15.44	16.25	82.9	14
26	Zehringen Elite by Strandes	June 5	July 5	12.6 tons	16.77	17.65	86.1	14⅓
27 East half	Zehringen	June 5	July 5	10.7 tons	16.01	16.85	85.5	15
27 West half	Mangold	June 5	July 5	9.6 tons	15.77	16.60	84.7	14

Results from early and late thinning.—In Bulletin 166 of this station the following statement was made with reference to the time of thinning beets. "Where conditions are favorable, considerable range may be taken as to time of thinning. With the weather coo and the soil moist, thinning may be safely done when the beets have attained a height of three to four inches. However, thinning is such a slow process that it would better be commenced on time, viz., when the second pair of leaves appear the plants should at least be bunched. The bunches may then safely be allowed to remain for a week or ten days before the beets are thinned to a stand of one beet in a place. If one could always be certain that the weather would be cool and soil moist, then there would not be the imperative necessity for beginning thinning early. If thinning be delayed until there exists drought accompanied by hot weather the growth of the plants may be seriously impaired, if the plants are not entirely destroyed."

The results of the experiment during 1899 lead us to change in no way the opinion expressed above, but rather enforce the conclusions heretofore drawn.

The month of July 1899 was especially favorable for late thinning of beets. It rained eleven days during the month an average of .314 inch each day, and on four other days during the month there was a trace of rain, the total rainfall for the month being 3.46 inches. The probability is that had the month of July been one of drought instead of one of abundance of rainfall the results might have been far different. Under the conditions which prevailed the late thinning seemed to be in no way injurious to the growth of the beets.

The yield of beets was not large enough to make the crop a paying one. This was not to be expected upon land which has been continually cropped for six years without the use of manures or fertilizers. The late planting occasioned by the failure to secure a stand from the first planting no doubt materially lessened the yield. The quality of the beets was all that could be desired. The per cent. of sugar and the per cent. of purity seemed to be affected in no way by the time of thinning.

Variety tests.—The variety giving the largest tonnage of beets

13.1 tons per acre was the Zehringen Elite from seed grown by Dippe Bros., Germany. The highest per cent. of sugar in the beets, 16.77, was found in the Zehringen Elite from seed grown by Strandes, Germany, and the highest per cent. purity 86.1, was also found in the Zehringen Elite from seed grown by Strandes.

In selecting the sample beets to be tested those were selected which seemed to represent fairly the beets grown on the plat. The size of the beets analyzed seems not to have affected the results. The smallest beets, those grown on the east one-half of plat 22 were the lowest in purity. The variety tests in no way prove anything. The conditions of the soil may have had more effect upon the yield than did the variety grown. The Zehringen Elite strains seemed to be better adapted to the soil and conditions present during 1899 than were the other varieties. Another season and on other soil the results might vary widely.

Fertilizer experiments with sugar beets —During the years 1897, 1898 and 1899 fertilizer experiments with sugar beets have been conducted upon some specially prepared plats. Before commencing this experiment it was determined to make the soil conditions uniform as to quality and treatment. In the spring of 1897 a space was measured off for 14 plats each 4x5 feet in size. The soil of this whole area was then removed to a depth of 24 inches, each layer of eight inches being thrown out upon boards by itself. A solid brick cement wall was constructed around each plat and to a depth of two feet below the surface of the ground. This wall was constructed so that there would be no possible chance for the beets in one plat to receive the benefit of the fertilizer applied to any other plat. After the construction of the wall the soil which had been removed was replaced in the inverse order of its removal, the eight inches removed last was returned first so that it would occupy its original place at the bottom. Before being returned each eight inches of soil was thoroughly mixed and then an equal number of pounds was put into each plat and packed. In this way all the plats were prepared, each layer of soil after being thoroughly mixed was returned to its original position.

During the years 1897, 1898 and 1899 the same experiment has been repeated, the various plats receiving each year the same kind of fertilizer received the previous year.

The small area upon which the experiments were conducted precludes the possibility of making any calculations of value as to the effect of the fertilizers upon the yield of beets. The only determinations of value hoped for are those which relate to the effect of the fertilizer upon the sugar content of the beets. We present the following tables which give the results of the three years work separately and also a table which gives the average of results for the three years.

TABLE SHOWING EFFECT OF FERTILIZER UPON THE QUALITY OF BEETS, 1897.

Plat.	Fertilizer used.	Rate per acre. Lbs.	Per cent. of sugar in beet.	Per cent. of sugar in juice	Per cent. solids in juice.	Purity of Juice
3	Sulfate of potash.....	544	17.06	17.96	20.08	87.56
4	Superphosphate......	544	17.29	18.18	20.12	90.36
5	Sulfate of potash...	277				
	Nitrate of soda.....	277	16.20	17.06	19.06	89.50
6	Nitrate of soda.......	544	16.71	17.59	19.49	88.40
7	No fertilizer.........		16.48	17.35	19.42	89.20
8	No fertilizer.........		16.23	17.09	19.22	88.60
9	Sulfate of potash...	277				
	Superphosphate....	277	16.61	17.49	19.14	91.38
10	Nitrate of soda.....	277				
	Superphosphate....	277	16.94	17.84	19.84	89.86
11	Sulfate of potash...	184⅔				
	Nitrate of soda.....	184⅔	17.43	18.35	20.08	91.22
	Superphosphate...	184⅔				
12	Muriate of potash....	544	17.73	18.67	20.72	89.94
13	Lime................	1089	16.49	17.36	19.30	89.44
14	Ground ph'phate rock	1089	16.18	17.04	19.08	89.14

TABLE SHOWING EFFECT OF FERTILIZER UPON QUALITY OF BEETS, 1898.

Plat.	Fertilizer used.	Rate per acre. Lbs.	Per cent. of sugar in beet.	Per cent. of sugar in juice.	Per cent. of solids in juice.	Purity of juice.
3	Sulfate of potash	1089	16.77	17.65	20.6	85.7
4	Superphosphate......	1089	16.39	17.25	20.1	85.8
5	Sulfate of potash ..	1089	16.72	17.60	20.4	86.3
	Nitrate of soda	1089				
6	Nitrate of soda	1089	13.78	14.50	18.4	78.3
7	No fertilizer		16.15	17.00	20.5	82.9
8	No fertilizer		17.05	17.95	20.4	88.0
9	Sulfate of potash ..	1089				
	Superphosphate....	1089	17.96	18.90	21.6	87.5
10	Nitrate of soda	1089	17.53	18.45	21.1	87.4
	Superphosphate....	1089				
11	Sulfate of potash..	1089				
	Nitrate of soda. ...	1089	16.48	17.35	20.3	85.4
	Superphosphate....	1089				
12	Muriate of potash....	1089	17.48	18.40	21.2	86.8
13	Lime..	1089	16.72	17.60	20.1	87.5
14	Ground ph'phate rock	1089	16.01	16.85	19.5	86 4

TABLE SHOWING EFFECT OF FERTILIZER UPON QUALITY OF BEETS, 1899.

Plat.	Fertilizer used.	Rate per acre. Lbs.	Per cent. of sugar in beet.	Per cent. of sugar in juice.	Per cent. of solids in juice.	Purity. of juice.
3	Sulfate of potash ...	1089	16.15	17.00	20.5	82.9
4	Superphosphate......	1089	13.78	14.50	18.1	80.1
5	Sulfate of potash ..	1089	14.25	15.00	18.6	80.6
	Nitrate of soda.....	1089				
6	Nitrate of soda.......	1089	13.11	13.80	17.6	78.1
7	No fertilizer		13.96	16.80	20.1	83.5
8	No fertilizer		15.15	15.95	19.3	82.6
9	Sulfate of potash ..	1089				
	Superphosphate....	1089	16.15	17.00	19.6	86.3
10	Nitrate of soda.....	1089				
	Superphosphate....	1089	13.02	13.70	16.5	83.0
11	Sulfate of potash ..	1089				
	Nitrate of soda.....	1089	14.44	15.20	19.0	80.0
	Superphosphate ...	1089				
12	Muriate of potash....	1089	15.87	16.70	20.5	81.1
13	Lime.......	1089	14.73	16.50	19.9	82.9
14	Ground ph'phate rock	1089	15.39	16.20	19.6	82.6

TABLE SHOWING EFFECT OF FERTILIZER UPON QUALITY OF BEETS.

Average of Results for 1897, 1898 and 1899.

Plat.	Fertilizer used.	Per cent. of sugar in beet.	Per cent. of sugar in juice.	Per cent. of solids in juice.	Purity of juice.
3	Sulfate of potash	16.66	17.53	20.39	85.38
4	Superphosphate.........	15.82	16.64	19.44	88.75
5	Sulfate of potash..... Nitrate of soda.......	15.72	16.55	19.35	85.46
6	Nitrate of soda	13.53	15.29	18.49	81.60
7	No fertilizer	15.53	17.05	20.00	85.53
8	No fertilizer	16.14	17.03	19.64	86.40
9	Sulfate of potash.... Superphosphate......	16.90	17.79	20.11	88.39
10	Nitrate of soda ...... Superphosphate......	15.83	16.66	19.14	86.75
11	Sulfate of potash..... Nitrate of soda ...... Superphosphate	16.11	16.96	19.79	85.54
12	Muriate of potash	17.02	17.92	20.80	85.94
13	Lime..................	15.98	17.15	19.76	86.61
14	Ground phosphate rock.	15.86	16.69	19.39	86.04

By a study of the above tables the two facts which seem to be most pronounced are: First, where nitrate of soda was used alone as a fertilizer the per cent. of sugar in the beets was very materially reduced as was also the purity of the juice. The average per cent. of sugar in the beets where nitrate of soda alone was used was 13.53, with the purity of the juice 81.60

The average of all plats where no nitrate of soda was used was 16.24 per cent. of sugar in the beets with a purity of juice of 86.63.

Second—Contrary, to the popular belief, the beets upon the plat receiving muriate of potash alone as a fertilizer contained the highest per cent. of sugar of any of the beets grown, and the purity of the juice compared well with that of all others. The per cent. of sugar in the beets fertilized with muriate of potash alone was 17.02 with a purity of the juice of 85.94. The average per cent. of sugar in the beets grown on all plats not receiving any muriate of potash was 15.82 with purity of the juice of 86.04. It is usually considered that the sulfate of potash is superior to the muriate of potash as a fertilizer for sugar beets but our experiments do not indicate that the sulfate is superior in any way to the muriate. This fact is important because the muriate of potash can usually be secured at a price materially less than the price asked for the sulfate of potash. Where nitrate of soda is used as a fertilizer for sugar beets it should be used in conjunction with the mineral fertilizers superphosphate and potash. Muriate of potash may safely be used as a fertilizer for sugar beets. The other chemicals used seem not to have any marked effect upon the quality of the beets.

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